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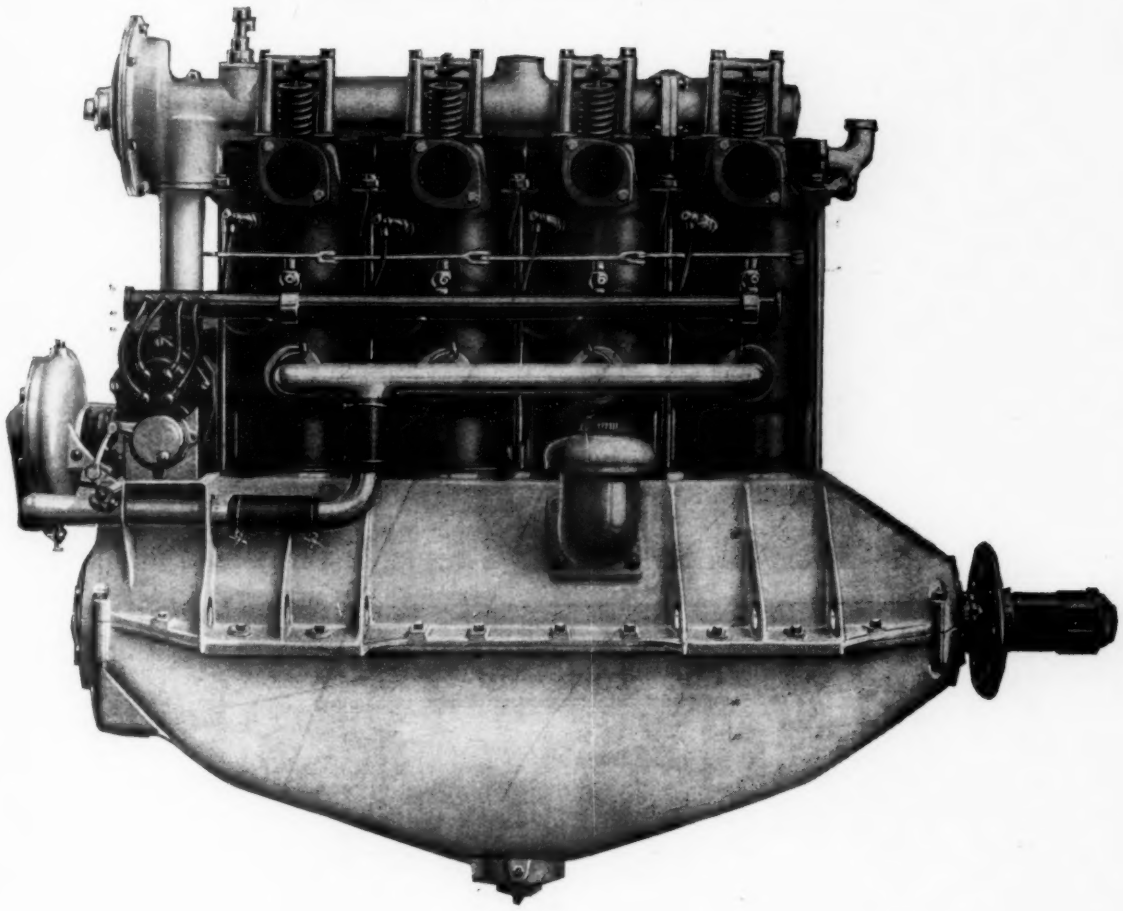

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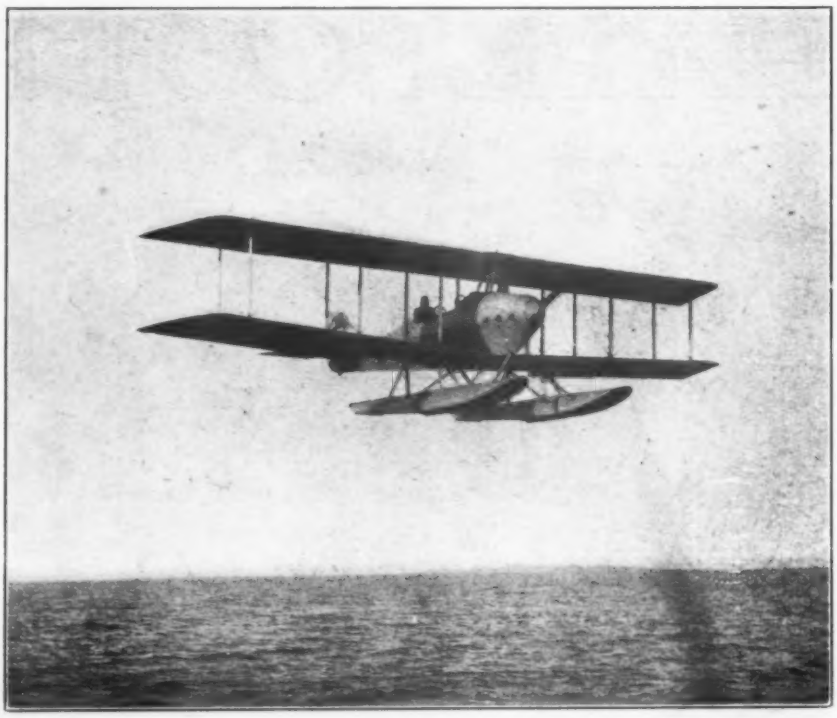

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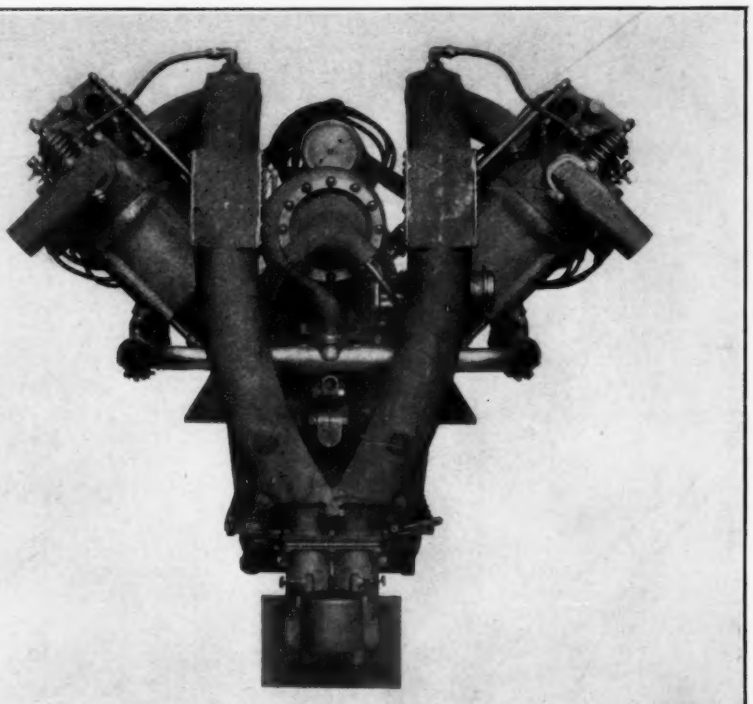

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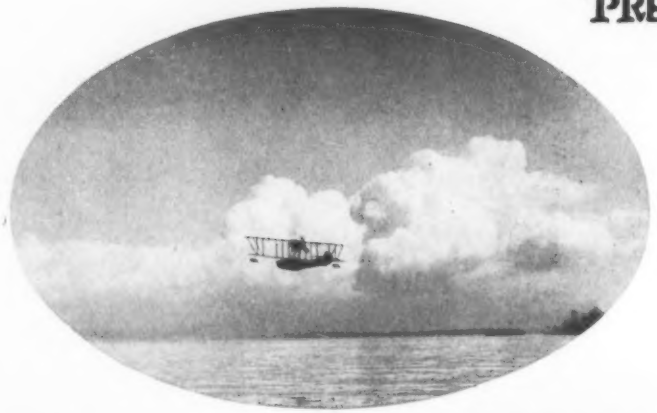

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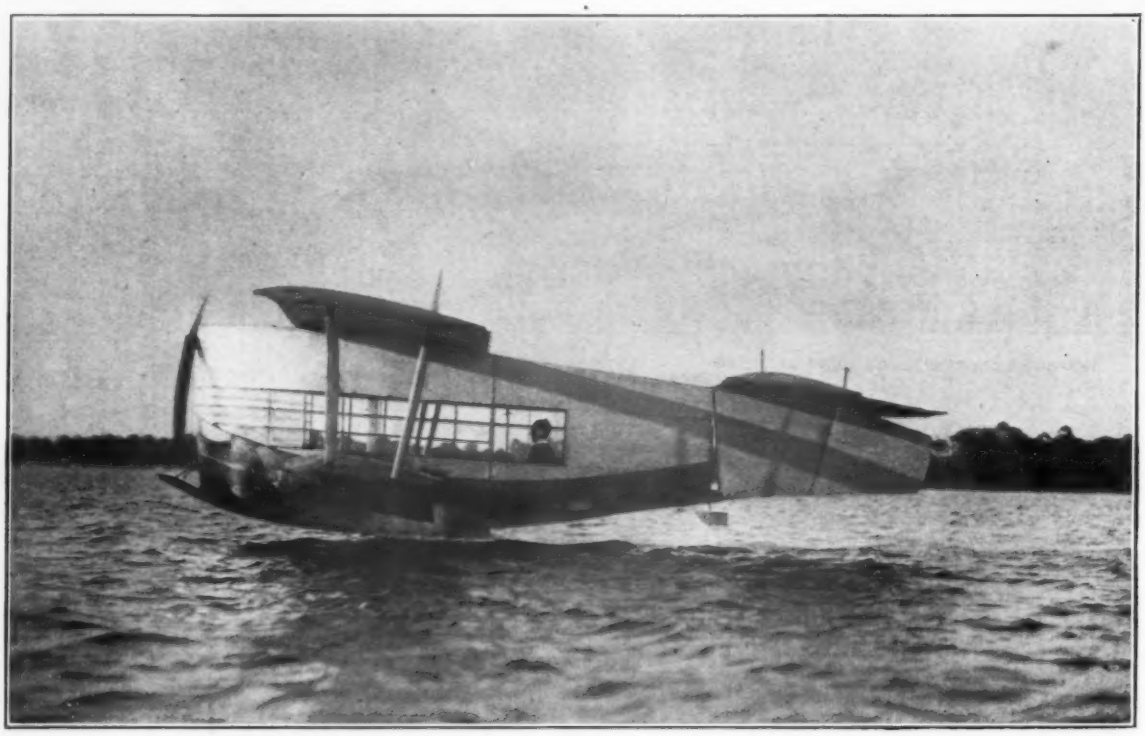

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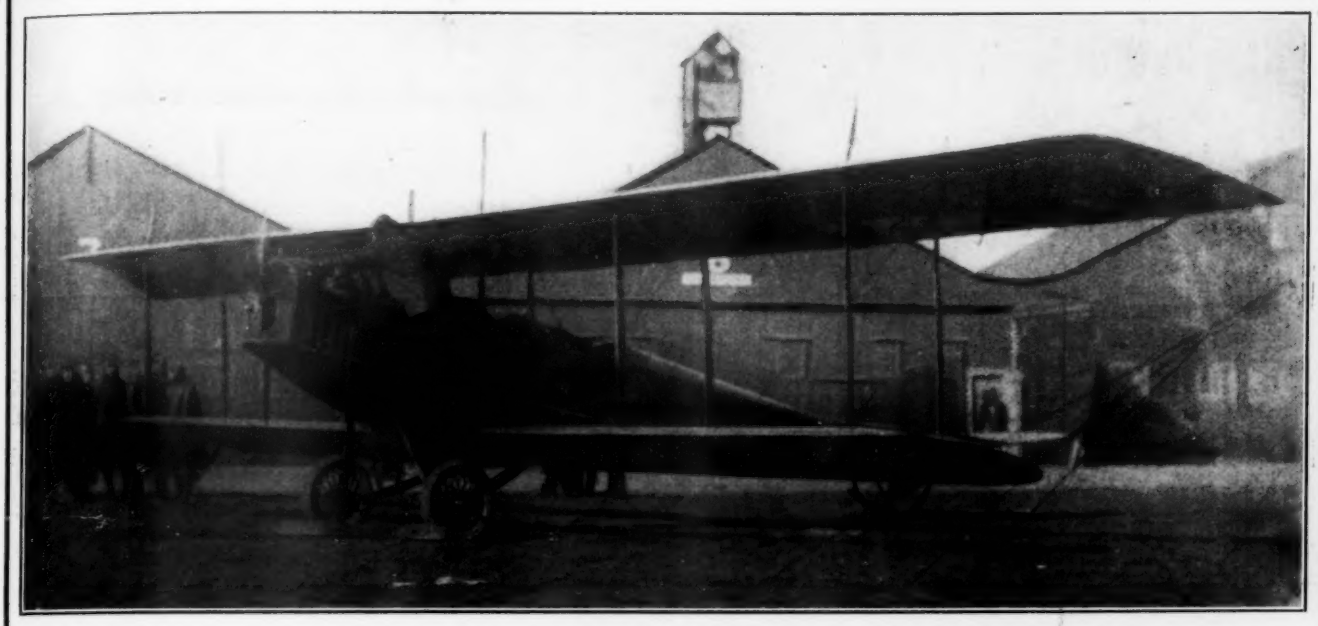

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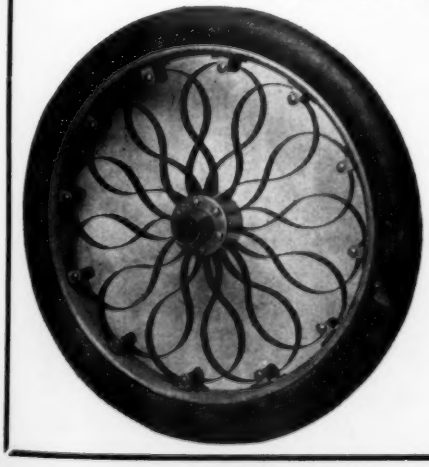

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AVIATION
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VOL. II. NO. 3

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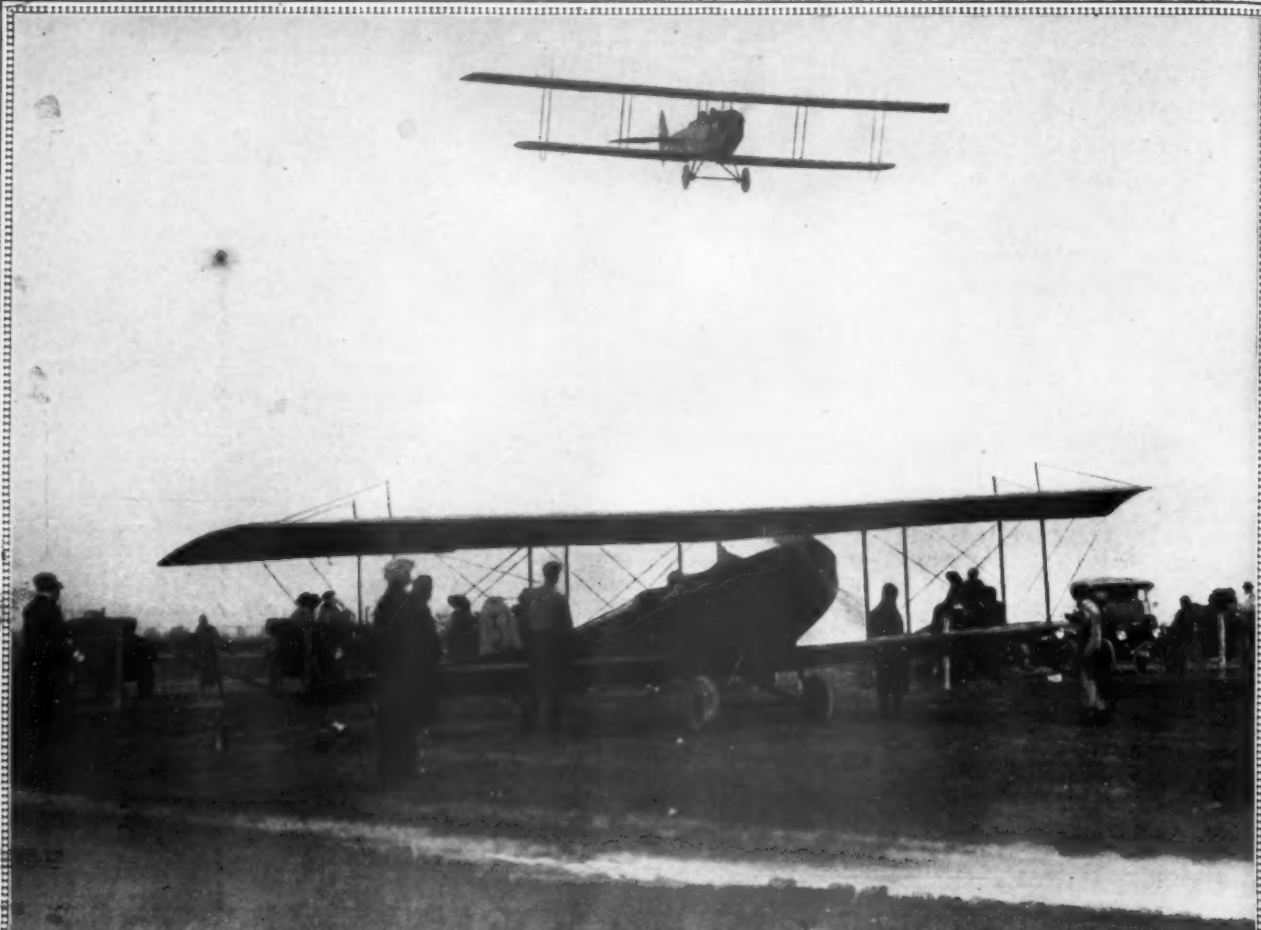

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MANAGING EDITOR
HERBERT M. WILLIAMS, B.S.

Vol. II | March 1, 1917 | No. 3

AS long as the principal use of aircraft continues to be for military purposes it is imperative that all the parts used in the construction of airplanes be manufactured in this country out of raw material produced here.

When Brigadier-General George O. Squier took charge of the development of Army aeronautics he mapped out a complete and concise statement of some of the lines along which scientific research was needed in order that the Army's aeronautic problem might be solved. Among these problems he said, only a few months ago, was the development of a wing covering for airplanes, which would meet the following requirements:

"It should weigh not more than five ounces per square yard. It should have reasonably great resistance to flame. It should be reasonably proof against action of salt water, moist air, extreme dryness and quick change of temperature. It should not stretch in any direction. It should have tensile strength of at least seventy-five pounds per inch width in any direction."

It is gratifying to know that this problem has been at least partially solved in this country. American cloth makers claim to have developed a fabric superior to the fine Irish linen which has been used almost exclusively up to the present time. Whether or not these claims of superiority are upheld, at least it is safe to say that a satisfactory wing covering made in this country from raw material produced in the United States will soon be available.

The spruce situation, at the present time is becoming acute. Large supplies of American spruce have been shipped abroad so that the stock in this country will soon be, if it is not already, running low. But this problem can be solved. Whether the solution lies in the use of steel construction or in a more rapid method for seasoning newly cut spruce, American ingenuity can be counted upon to find that solution.

It is gratifying to have the realization brought home to us that there is no insuperable obstacle to the production of American airplanes, American in the sense that everything that goes into them will have been produced in the United States.

Training Military Aviators

The training of military aviators requires an amount of care, detailed thought and material which many men, even those closely associated with the aeronautical industry, fail to appreciate. Every training machine requires its staff of pilots, mechanics, motor-truck drivers, motorcycle drivers and others. The training of military pilots requires the constant attention and careful supervision of military men themselves, trained soldiers who, at the same time, are fliers. If the students' course of training is not to be simply a story of delays and wasted time every school must be equipped with a training machine for every pupil who is in training.

It is possible to train five men to a machine, but when wastage and temporary repairs are taken into consideration one machine for every pupil is by no means an excessive allowance. Both French and English experiences support this statement. Recent disclosures in the House of Commons have shown that a French training school designed to train seventy men at a time is equipped with seventy training machines and English schools designed to train fifty men at a time are equipped with fifty training machines.

It has been truly said that a first-class mechanic is worth more to a training school or a flying squadron than a first-class pilot. The mechanics are more difficult to recruit in the first place, for almost any young man is willing to learn to fly. They are more difficult to train, and once trained their efficiency or inefficiency determines the amount of time the pilots can spend in the air. A large number of machines means a large number of hangars. It means a large squad of men doing practically nothing but cleaning those machines and hangars. It means providing these men with all the supplies and organization of a commissariat department and a quartermaster's department as well as with quarters in which to live.

Military aviators have to be instructed, and thoroughly instructed, in the military art. They must understand the organization of the units in every branch of the service and they must have some appreciation of what a soldier's life really is. They require a thorough grounding in the knowledge of strategy and tactics. Perhaps the least important side of their instruction is the instruction they receive in the air.

Major-General Leonard Wood said recently:

"The Allies have learned the lesson that it is impossible to turn out aviators in jig-time."

This statement has a special application in this country where the output of airplanes and accessories is at present limited, where almost no men are available who are trained in the duties of administration and where the work of organizing training schools for large numbers of civilian pupils has only just commenced.

The Application of Ball Bearings to the Airplane

By W. L. Batt, M.E.

Of the Hess-Bright Manufacturing Company

The application of ball bearings to the airplane differs in no essential from their employment in other and better known mechanisms. The success of this type of bearing in many of the more familiar fields, as in that of the automobile and the machine tool, has been so marked as to render its use there quite a matter of course. Engineers who are responsible for the design in such fields, have become acquainted with the various forms and types of ball bearings and their relative values.

This article must, of necessity, cover what will be, to many, some old ground; it is unfortunately true, however, that the maker of ball bearings who is really interested in their proper use, finds, all too frequently, that they have been misused, even by those who are supposed to be thoroughly informed concerning them.

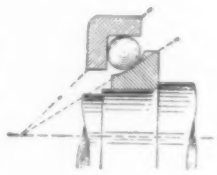

FIG. 1

The advantages which may accrue from the use of a thoroughly good ball bearing lie principally in its increased efficiency as compared with that of the ordinary sleeve bearing, and in its freedom from the necessity for frequent attention. Obviously the increased efficiency of a unit mounted on bearings that are well-nigh frictionless, makes possible a lesser weight for the same power output, or a greater effective power from the same weight. This is a characteristic having its maximum importance in the airplane application. Not a poor second is that element of increased reliability, particularly as applied to that bearing which takes the thrust of the propeller.

The plain sleeve bearing may be made reasonably dependable by careful attention to material, workmanship, and lubrication; but the thrust washers that would be used, were ball thrusts not available, are a very frequent source of trouble at speeds such as are encountered on the propeller shaft. It is further true that when a ball bearing does fail, that failure is almost invariably a gradual one, whereas the failure of the sliding bearing is all too frequently accompanied by a seizing of the surfaces, and the necessity for an immediate stoppage. The aviator realizes most effectively this difference.

The development of the annular ball bearing over the past eighteen years has been steady and continuous. From a poorly designed and cheaply made element, with capacity totally inadequate, it has slowly progressed to the present day production, capable of sustaining very large loads and having a wide range of satisfactory speed performance. Ball bearings are successfully carrying loads of thirty to fifty thousand pounds; and, where there is a demand for some exceptionally high speed, it is most frequently met by the use of this type of bearing.

The ball bearing of the early day was usually made from a soft steel, case-hardened. More frequently than not, this was poorly done, and the harder shell was prone to come loose from the soft center. The races were of the cup and cone type shown in Fig. 1, and little attention was paid to producing smooth surfaces. A little too generous use of the wrench was apt to overload this type of bearing, because the setting of the races was determined by a nut.

The developments of succeeding years, laid upon a basis of experimentally determined fact, produced a ball bearing of a very different character. To-day there is scarcely a field of possible application that does not bear witness to the sturdy qualities of the better class of modern ball bearings.

Broadly speaking, there are two types of ball bearings available for airplane service, and these are:

1. The radial bearing, which is primarily adapted to sustain loads at right angles to the shaft axis. Fig 2 illustrates such a bearing.

2. The thrust bearing, whose function is to carry loads parallel to the shaft axis; this is a sort of step bearing. It is shown in Fig. 3, as made by the Hess-Bright Manufacturing Company of Philadelphia, Pa.

The radial bearing consists of an inner and an outer race and a circle of balls running between. The balls are held securely in a light and stiff cage, which in the bearing illustrated, is of a two-piece, spherical form and rivetted together. The grooves in which the balls run, are deep, and the curvature of the groove is very slightly larger than that of the ball. This results in a maximum of radial capacity, and a considerable end-thrust capacity, too.

The thrust bearing consists of two parallel rings, and a circle of balls. One of the races rotates with the shaft, and the other is fixed in the housing. The efficiency of this type of bearing is perhaps better than that of any other form of bearing. The coefficient of friction of a well-constructed bearing of the thrust type, is about 1/15 of one per cent, whereas that of the radial bearing is about ⅛ per cent. These losses are, of course, small in comparison with those of the sleeve bearing.

From time to time, various modifications of these two types of ball bearings have appeared, and some of these have merit. There is the one having two rows of balls that are arranged at an angle to the vertical, and is mounted like the regular radial bearing. It has a certain amount of thrust ability in addition to its radial capacity. There is, also, one having two rows of balls, running on a spherically formed outer groove. The feature of this is that it may adapt itself to extreme inaccuracy of mounting, or a bent shaft will run without being cramped.

Thrust bearings are offered in types that differ, their difference being largely in the form of groove in which the balls run. For each of these there is frequently some service for which it is best fitted. For the large part of every-day service, the form shown in Fig. 4 is usually given the preference. This has the advantage of simplicity and ruggedness, coupled with a maximum of life and a minimum of friction loss.

Ball bearings have been successfully applied to about every possible bearing point by one manufacturer or another. They are being used for crankshaft work most extensively on the smaller block engines; less widely on large engines because of the fact that the mounting becomes more complicated and expensive where the central bearings must be threaded over the checks of the crank and held in place by split sleeves or adapters. A combination which has been used, is that of sleeve bearings on all save one main bearing at the end of the motor. Here a large size ball bearing is used, and this is locked against end-wise movement. Such an arrangement locates the crankshaft against

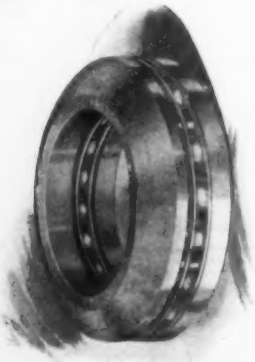

FIG. 3

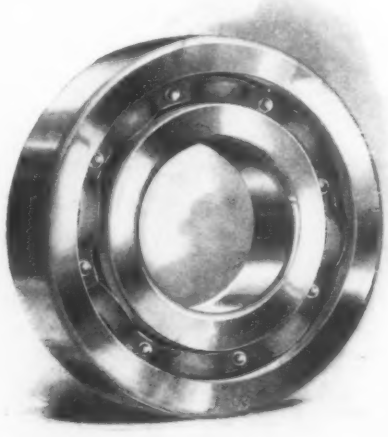

FIG. 2

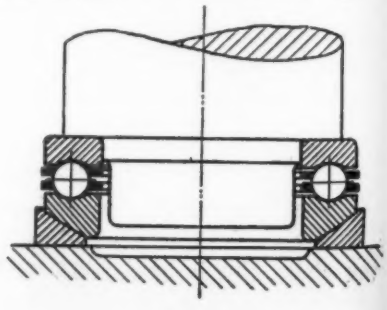

FIG. 4

movement whenever the engine is off a horizontal plane and carries the gear load on the ball bearing. It will be evident, however, that with such a mounting, the freedom of the sleeve bearings must be kept at a minimum, otherwise the ball bearing would soon be overloaded.

The thrust of the propeller is always taken on a ball bearing and this is usually of the thrust type shown in Fig. 5. In the case of the smaller planes, a radial bearing of special design to enable it to carry more thrust, has sometimes been used. This is not, in the opinion of the writer, the best practice. The thrust bearing may be of the two-direction type, or two separate and opposed bearings may be employed. The former offers the more compact arrangement. The illustrations in Fig. 6 show the two methods of mounting the thrust bearing.

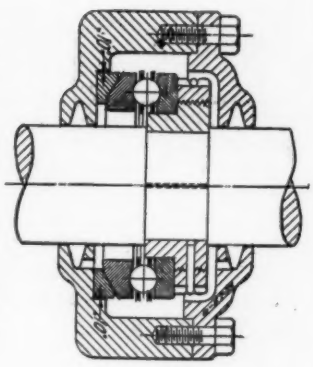

FIG. 5

On that type of propeller mounting where the propeller is carried on a lay shaft, which is in turn driven from the crankshaft, a new condition is introduced which necessitates the use of radial bearings to support the lay shaft in addition to the thrust bearings. The lay shaft may, of course, be driven by chain, or by gear.

gears are of the spur type. The housing is pressed steel, and supports all bearings rigidly. A single radial bearing is mounted on the crankshaft extension, and serves to carry the load from the driving gear.

On another mount for similar service, shown in Fig. 8, the sleeve bearing on that end of the crank is made unusually long in consideration of the extra load imposed upon it. The lay-shaft is carried on two standard radial bearings and between these, the two-direction thrust is mounted. The gear load is overhung.

The ball bearings that are employed in the latter illustration are typical of a good selection. The radial bearing next the propeller is size No. 313. This has a rated capacity of about 2000 pounds at the speed of 1100 revolutions per minute, the propeller speed. The bearing on the other end of the shaft is No. 6410 and this has a capacity of the same amount. The thrust bearing has a bore of 60 millimeters and a capacity of 1500 pounds at a speed of 1100 revolutions per minute. The engine torque is slightly over 6500 pounds at 1225 revolutions per minute. The normal thrust from the propeller is 780 pounds, though the maximum thrust

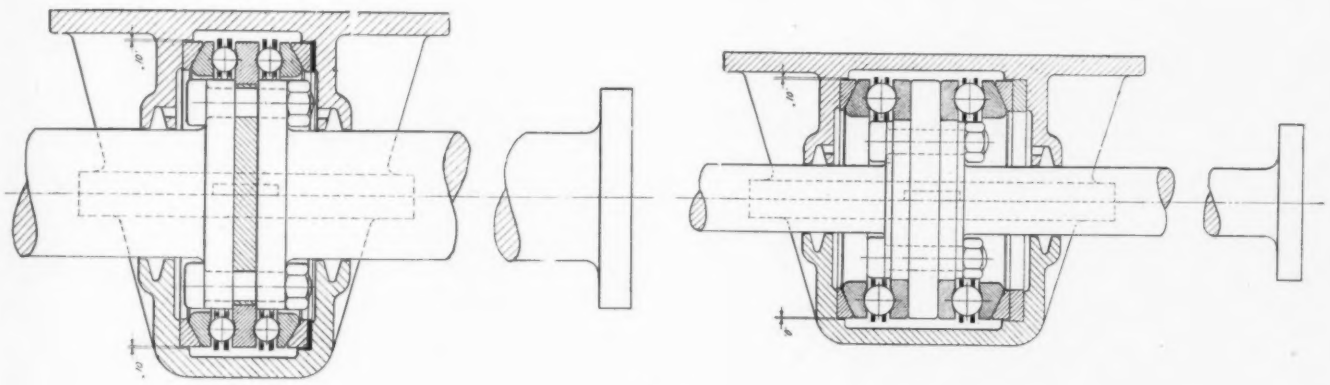

FIG. 6

In the first case, the one engine will ordinarily drive the two propellers. Two radial bearings will be used on each propeller shaft, and a thrust mounting that will carry thrust in either direction. This method of drive is fast becoming obsolete as the demand for more power increases.

In the second case, where the propeller shaft is gear-driven from the engine shaft, the power transmitted is constantly increasing, and bearings of quite large size are necessary to carry the loads that are now encountered. The selection of a bearing for this service must take into consideration the possibility of loads far in excess of those due to engine power alone. A broken propeller or any unbalanced condition of the propeller may entail really enormous bearing loads, radial as well as thrust.

The ball bearing engineer has been more or less at sea in the selection of bearings for airplane work because of the varied requirements of different purchasers as to overload capacities. His only recourse has been to select bearings that were reasonably large for the service expected of them and to hope that no untoward loads might be imposed upon them. The ability of a high-grade ball bearing to sustain very large overloads for a short period of time, has made such a course reasonably safe.

Fig. 7 illustrates a typical application of ball bearings to a geared drive. In this case, the

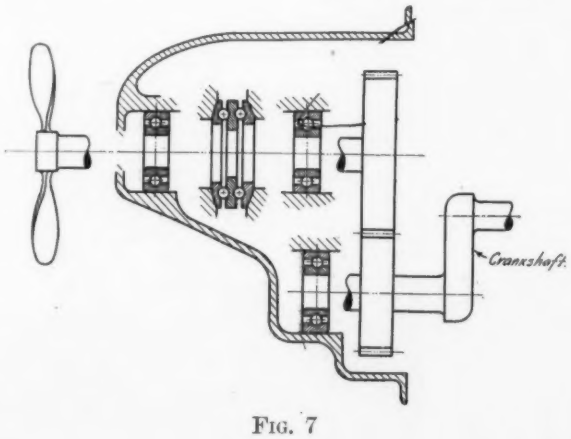

FIG. 7

at starting exceeds that amount slightly.

It is impossible, in the limits of this article, to attempt to give the fullest details of the mounting of ball bearings. In general, the following requirements must be observed. The inner race of the radial bearing must be a permanently tight fit on the shaft; otherwise the continued action of the load, concentrated on the short shaft length corresponding to the bearing width, will peen down the shaft, and cause serious cutting both of shaft and bearing. A reliance on a drive fit alone is not sufficient; the inner race should be bound between a well set up nut and a good shoulder on the shaft. The outer race should be a nice slip-fit in the housing. This will make it possible for the race to slowly creep around, due to the vibration and thus the load will be distributed over the entire race section.

In the case of the thrust bearing a little less importance attaches to the mounting. It is only primarily necessary that the race which rotates with the shaft be carried against a good shoulder at right angles to the shaft. Should it be preferable to use the thrust bearing with flat plates, it is essential that the supporting surface be truly machined and exactly parallel to the shaft shoulder, else the load will not be carried on the full circle of balls. It is for this reason that the thrust bearing with aligning washer will always be used where possible.

The lubrication of ball bearings must respond to a few very simple requirements. That a small amount of lubricant must always be provided, should be more obvious than it sometimes appears to be; that the lubricant should be free from such deleterious elements as would tend to destroy the finely polished surfaces of the bearing is apparent.

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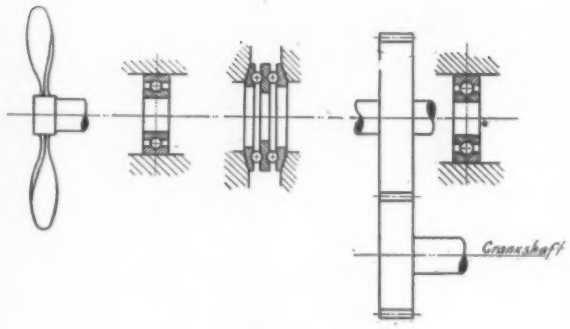

FIG. 8

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It is interesting to note that this was the largest wing ever tested in this country, the overall span being 92 feet.

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The wing on but one side of the boat was tested. This included its length from the tip of the engine panel and the boat sidewalk. The enormous size of the wing necessitated the design and erection of a heavy supporting jig. The cross beams of the jig replaced the boat sidewalk and upper engine panel. The female wing hinges were bolted to these horizontal beams, and the wing was pinned to the hinges in the usual manner, excepting that it was inverted.

H-12 WING TESTED WITH LOAD OF 60 PEOPLE

To avoid confusion in the following discussion, the panels will be designated as in actual flying conditions. The lower panel in the test is the upper panel in flight.

MANNER OF LOADING

Reference—"*Admiralty Instructions for Sand Loading Tests of Aeroplane Wings,*" February 28, 1916.

The loading required is given by the formula:

$P = N(W + W_1 - W_2) - W_2$, in which P = weight of sand on wing surface; N = required factor of safety; W = net weight of machine; W_1 = useful load carried, including petrol, pilot, passenger and any other useful load, and W_2 = weight of wings.

For the test requirements of the present case these quantities are as follows: $N = 4$; $W = 5934$ pounds; $W_1 = 2044$ pounds; $W_2 = 767$ pounds; $P = 28{,}113$ pounds.

From the stress analysis of the H-12 wing framing.

Upper plane carries 69% of the load, or $0.69 \times 28113 = 19{,}400$ pounds.
Lower plane carries 31% of load, or $0.31 \times 28113 = 8{,}700$ pounds.
Total, 28,110 pounds.

From the load carried by the upper plane that borne by the engine panel must be substracted.

Span of upper plane, 1112 inches.

$$\text{Load per inch run of upper plane} = \frac{19400}{1112} = 17.45 \text{ pounds.}$$

Span of engine section = 132 inches.
Load carried by engine section = $132 \times 17.45 = 2300$ pounds.
Net load carried by upper plane = $19400 - 2300 = 17100$ pounds.

$$\text{Load carried by one upper plane} = \frac{17100}{2} = 8550 \text{ pounds.}$$

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Total, 12905 pounds.

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(a) Bags of sand totaling in weight the normal load on the wing to take up slack wires, etc. Center of gravity of loading halfway between front and rear spars. Load stood one hour.
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(c) Loose sand equal in weight to four times the normal load on the wing. Center of gravity of loading 50% of chord length from leading edge. Corresponds to maximum speed.
(d) Loose sand equal in weight to 5.9 times the normal load on the wing. Center of gravity of loading approximately 50% of chord length from leading edge. To test maximum factor of safety.
(e) A loading of 60 people averaging 150 pounds each.

The loose sand was loaded by filling in a crate acting as a template to bring the center of gravity of loading in the desired position. The shape of the template was obtained from measurements of pressure at different points on an aerofoil.

METHODS OF MEASURING DEFLECTIONS

All gross deflections were obtained by direct measurement from the floor as reference. Net deflections at strut joints were found by computing the amount of vertical motion due to the angular stoop of the jig and the vertical movement of the upper cross beam. The sum of these two was then subtracted from the gross deflections.

VERTICAL DEFLECTION

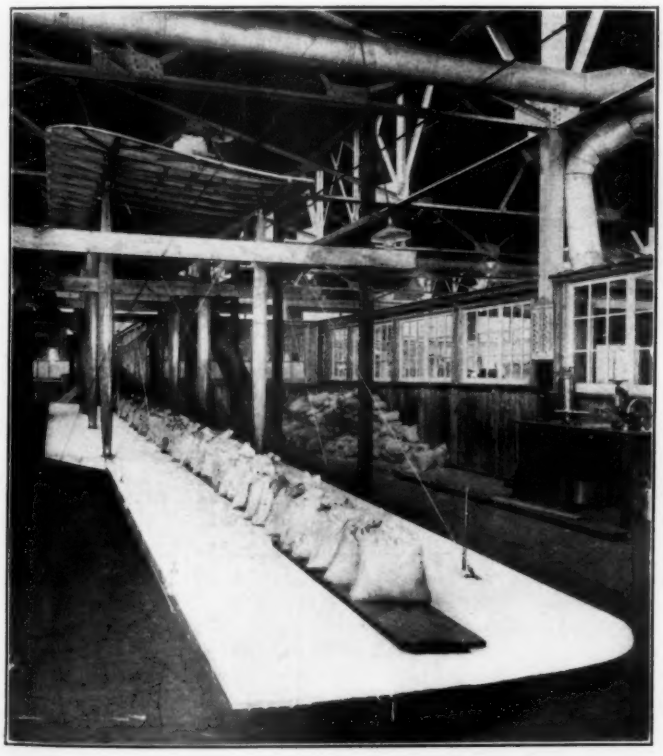
The amount of vertical motion at each strut joint was recorded by a vertical rod resting on the floor and passing up through holes in aluminium straight edges at the strut joints on the upper and lower spars. A record of the motion was made by scratching fine lines on the rods at the straight edges.

HORIZONTAL DEFLECTION

Measured near the wing tip at the leading edge of the upper wing by a carpenter's square, placed with one leg on the floor, the other leg vertical and against the leading edge.

BOWING OF SPARS

Measured by the movement of an aluminium straight edge tacked on the spar at the center of the span, over a long straight edge suspended by veneer strips from the spar near the joints.



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DEFORMATION OF JIG

A bar pendulum pivoted to the overhead spar next the jig and swinging along the spar beneath revealed the angular stooping of the wing support. The movement of the pendulum at its lower end was recorded on a plate fastened to the spar there. By special compensating screws the angular stoop could be corrected, so as to make the pendulum stand always at zero reading.

DATA ON TESTS—NORMAL LOADING

Load on upper plane	1,968 pounds.
Load on lower plane	1.000 pounds.
Total	2,968 pounds.

Center of gravity of load halfway between the front and rear spars. Effects noted at full load.

1. All drop wires slack.
   Vertical deflection at tip of upper plane.
   (a) At full load ... 3.5″
   (b) At end of one hour ... 3.8″
   (c) At removal of load ... 0.9″

TEST NO. 1—FOUR TIMES NORMAL LOAD

Loading started	3:25 P. M.
Loading finished	5:12 P. M.
Load on upper plane	8,550 pounds.
Load on lower plane	4,355 pounds.
Total load	12,905 pounds.

Center of gravity of loading 30 per cent of chord length from leading edge. Effects noted with load applied:

(a) All drop wires slack.
(b) Fore and aft wires from upper rear spars to lower front spars slack at all stations.

No important deformations were noted during this test or at its conclusion.

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Loading started	10:35 A. M.
Loading finished	12:30 P. M.
Load on upper plane	8,550 pounds.
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Center of gravity of load 50 per cent of chord length from leading edge. Effects noted with load applied:

(a) All drop wires were slack.
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MAXIMUM LOAD TEST—5.9 TIMES NORMAL LOAD

Test started	3:27 P. M.
Test stopped	4:55 P. M.
Load on lower plane	6,485 pounds.
Load on upper plane	12,705 pounds.
Total load	19,190 pounds.

Center of gravity of loading approximately 50 per cent of chord length from leading edge. Effects noted with load applied:

(a) Third rib from (6) in upper plane broken.
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The accompanying photograph of the loading of people amounting to 9930 pounds, which is only about one-half the maximum tests load, gives a good idea of what the wing really sustained.

FINAL EXAMINATION

An examination was made by a representative, John M. Rogers, of the Heat Treating Department, and Burr Rogers, of the Inspection Department. The following results were noted:

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Front Spar	Upper Wing. Station	Rear Spar
0.2″	5-6	0.15″
0	4-5	0.061″

CONCLUSION

The wing withstood the load specified by the Admiralty instructions without permanent deflection or signs of failure. No recommendations are made.

As an interesting check upon the loads carried by the lift cables of greatest stress, the elongations during test No. 1 and 2 were measured over a known length. Test pieces of the same cable were then pulled in a Riehle testing machine and a stress strain diagram obtained. From this stress strain diagram and the elongation of the cables during the test on the H-12 machine, the tensions in them were computed. These computed values agree closely with the value obtained from the stress analysis of the machine.

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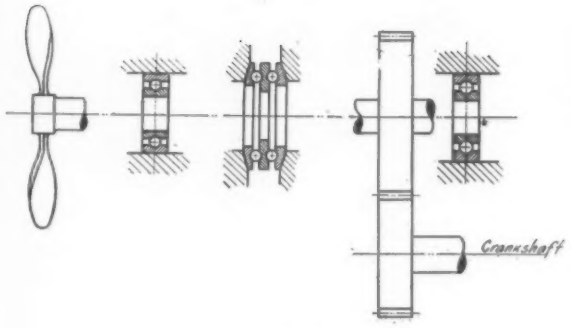

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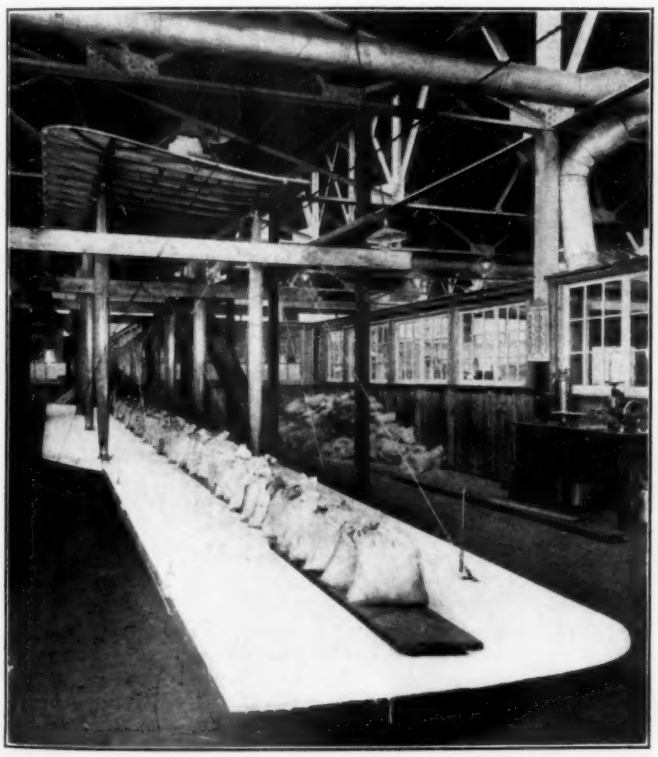

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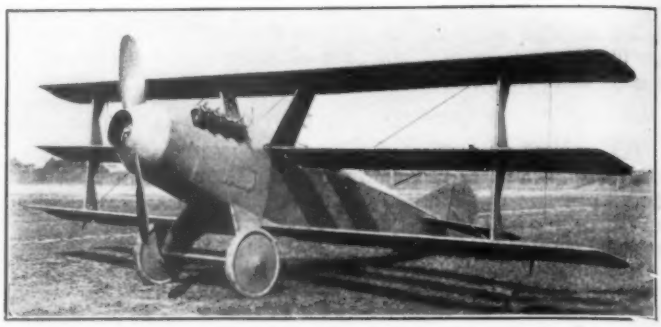
EXAMPLES OF PURSUIT TYPE AIRPLANES

GERMAN ALBATROSS OF 1916

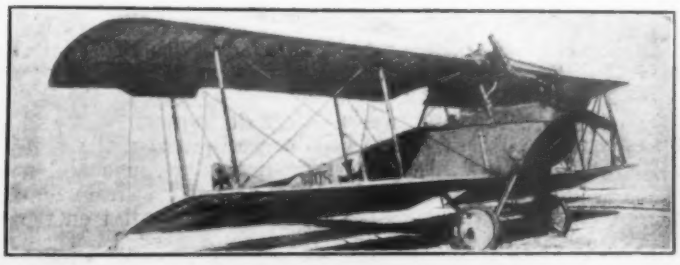


THE CURTISS TRIPLANE

Photo. from Underwood and Underwood

A NIEUPORT PURSUIT MACHINE

EXAMPLES OF GERMAN ARMED BIPLANES



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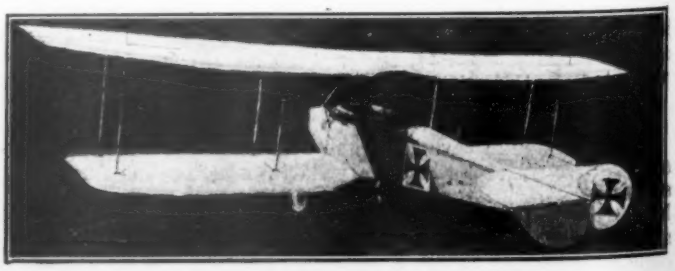

AN AVIATIK GUN-CARRIER

Course in Aerodynamics and Airplane Design*

By Alexander Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

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PART II—SECTION 2

Land Pursuit Machine; Land Gun Carrying Machine; Twin Engined All Round Machine

The High Speed Scout or Land Pursuit Type

The high speed scout or pursuit type has in the present war assumed a very great importance. In the War Department memorandum on "Military Airplanes," its functions are well defined:

"By virtue of its tremendous speed and climbing ability, it can dodge and outmaneuver its larger enemy, maintaining an effective fire with its machine gun, at the same time presenting a small and bewildering target. This is an ideal machine for tactical reconnaissance. It can even drop a few bombs where they will do most good."

The United States Army memorandum gives the following figures pertaining to this type:

TABLE 1.

LAND PURSUIT TYPE.

Horsepower	110
Type	Tractor
Number of men	1
Military load, pounds	200
Fuel load, pounds	150
Miles, radius of action, full power	315
Climb, feet in 10 minutes	8000
High speed, miles per hour	115
Low speed, miles per hour	43
Factor of safety	7.5
Percentage demand in war	21.0

Very few machines of this type have been built in America. Abroad such machines have been used in great numbers, but little information is available for recent French and English types, such as the Nieuport, Morane, Vickers, Bristol, Sopwith, etc., with light rotary engines of between 80 and 130 horsepower. Lately very light and more powerful 150 horsepower V-type Hispano-Suiza engines have been employed in great numbers.

We may say that an average of 120 horsepower is used in this type, that it is a single seater machine, almost always a biplane with the smallest possible wing spread, a tractor with a light machine gun firing either through the propeller or above the wings.

English opinion based on experience in the war supports an inherently stable machine which the pilot can leave uncontrolled for a short period while engaged in combat or other functions. To obtain inherent stability in this type is a difficult problem. The high loading per square foot of area is not conducive to stability, and the employment of correct fin areas and dihedrals is still a problem. The high loading also introduces difficulties from the point of view of stresses in the wing structure. Nothing lower than 7 pounds per square foot of wing area seems possible.

With the production in the United States of such engines as the General Vehicle Company's Gnome and the Hispano-Suiza, there is to be expected a very rapid increase in the number of American speed scouts. These light and powerful engines will enable the weight per horsepower to be diminished and the speed and climb to be increased until European practice is equaled.

Data for Pursuit Type, 100 Horsepower Engine

In Table 2 some data has been collected bearing upon some of these types. Little detailed information is available, but these figures and illustrations should be sufficient to give a general idea of present development.

TABLE 2.

DATA FOR HIGH-SPEED PURSUIT MACHINES.

Model	Nieuport	S.P.A.D.	Bleriot	Curtiss
Engine	80 h.p. Le Rhone	150 h.p. Hispano-Suiza	150 h.p. Hispano-Suiza	triplane OXX-2 100 h.p.
Number of men	1	1	1	..
Endurance at full speed (hours)	2½ to 3	..	..	2½ to 3
Maximum speed (miles per hour)	..	125	125	120
Minimum speed (miles per hour)	..	..	..	56
Climb in 10 minutes (feet)	6,000-7,000	9,200	9,200	10,000
Climb to 3,200 feet (minutes)	..	3	3	..
Climb to 6,400 feet (minutes)	..	6	6	..
Climb to 9,600 feet (minutes)	..	10½	10½	..
Total weight (pounds)	..	..	..	1,218
Useful load	..	460	460	..
Pounds per horsepower	..	..	..	12.18
Area wings (square feet)	..	185	185	143
Wing loading (pounds per square foot)	..	..	..	8.5
Wing area per brake horsepower (square feet)	..	1.23	1.23	1.43
Span top plane	24′ 6″	..	..	25′ 0″ all three planes
Chord top plane	3′ 11″	..	..	2′ 0″ all three planes
Aspect Ratio top plane	6.15	..	..	12.5 all three planes
Span bottom plane	23′ 0″	..	..	..
Chord bottom plane	2′ 4″	..	..	..
Aspect ratio bottom plane	9.9	..	..	..

Data for More Powerful Pursuit Types

So rapid is the development of the foreign military airplanes that it would seem as if the speed scout fitted with a rotary engine of about 100 horsepower, is now being displaced by a more powerful type.

It is interesting to note that in the S. P. A. D. and Bleriot types the climb does not apparently fall off with altitude, showing probably that the difficulties of maintaining the power of the engine at high altitudes have been successfully met.

Trend of Design in the Pursuit Type

Among the salient features of this type is the very small weight per horsepower, 12 pounds or thereabouts, as compared with the 18 or 20 of the large reconnaissance type. There is a tendency to employ large aspect ratios—the small weight per horsepower and small wing surface permitting the chord to be cut down considerably. Thus we find in the Nieuport aspect ratios of 6.15 and 9.9; in the Curtiss triplane 12.5 on all the planes. In the triplane the extraordinary aspect ratio of 12.5 is rendered possible by the distribution of the carrying surface among three planes instead of two. Stream-lining to the very limit is another feature.

Hitherto German constructors do not appear to have sought the reduction of head resistance to any great extent, but the new Albatross shows a beautiful body, struts reduced to a minimum, and the stream-lining carried to the extent of a hemispherical nose-piece over the propeller boss. In the Nieuport scout the V-strut system gives both lightness of construction and aerodynamic efficiency. The wonderful improvement of the Curtiss triplane with no larger power, as compared with its predecessor, the "Baby" scout, is due in part to the large aspect ratio which counterbalances the inefficiency of the triplane, but more to the clever *K* strut construction with the two

* This Course commenced in the August 1, 1916 issue of AVIATION AND AERONAUTICAL ENGINEERING will be completed in 24 issues.

tubular struts stream-lined in, and the stream-lined chassis construction. Such valuable yet simple ideas in the design of this type are well worth attention.

German practice in every respect seems to be following French practice very closely for this type. In the February 15 issue of AVIATION AND AERONAUTICAL ENGINEERING, some of the latest information at hand shows that the small biplane, such as the Albatross just mentioned and the new Fokker biplane are being built in great numbers. The Fokker biplane has apparently superseded the monoplane.

Guns on the Pursuit Type

However stable a machine may be, and even if it is equipped with a stabilizer or automatic pilot, it seems impossible that a pilot should at the same time be a gunner capable of firing in all directions. The light machine guns which are employed, are probably fired straight ahead towards the enemy machine which the pilot is approaching. They may be

(1) fired through the propeller, which is suitably protected for deflecting stray bullets.
(2) fired through the propeller with a suitable synchronizing mechanism as on the Fokker (see appended reference).
(3) placed above the wing within reach of the pilot as on the Nieuport.

Land Gun Carrying Machines

For the land gun-carrying type of airplane the War Department memorandum specifies:

TABLE 3.

Horsepower	130
Type	Tractor
Number of men	2
Military load, pounds	500
Fuel load, pounds	425
Miles radius of action, full power	360
Climb, feet in 10 minutes	3100
High speed, miles per hour	77
Low speed, miles per hour	45
Factor of safety	7.0
Percentage demand in war	4%

If any criticism is to be ventured with regard to the memorandum, it is on the score of too implicit faith in the all round twin-engined machine, and neglect of the importance of the gun-carrying machine of this type. Most of our information as to this type comes from the splendid descriptions of captured German machines in *L'Aérophile*. The Germans have succeeded in providing this type with one or two machine guns, with a good range of fire and arrangements for throwing bombs, and yet with excellent performance.

In Table 4 some useful data has been collected, and photographs of the Aviatik and L. V. G. shown herewith, are good examples of this type. Recent development in America has shown the necessity of standardized tests at various altitudes and it is interesting to note that figures are given for speeds on the ground and at various standard altitudes; while maximum altitude, or "plafond," as the French term it, is also specified.

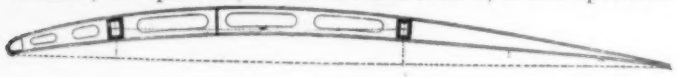


FIG. 1. AVIATIK WING SECTION

These German machines, as regards climb, are on a par with the American unarmed reconnaissance machines. They appear to be much superior in maximum speed. Their percentage of useful load is greater. By careful construction and probably with a lower factor of safety, they actually have a lower loading per brake-horsepower, even when carrying two machine guns, the ammunition required, and bombs and bombing devices. This indicates how much room there still is for improvement in American machines as regards weight saving.

They are short machines, with large stabilizing planes, but comparatively small control surfaces. The wings are very heavily cambered, as shown in Fig. 1, yet look as if they were efficient, and deserve careful study. They appear to be an improvement on the wing sections commonly employed. The wings also appear to be set at large angles to the body, so that the propeller axis is coincident with the line of flight at normal angle of incidence, and at a small angle to the line of flight in climb.

Their design is characterized by a robust lightness due to careful utilization of material throughout, and probably a uniform factor of safety.

TABLE 4.

DATA FOR GERMAN TWO-SEATER GUN-CARRYING MACHINE (From *L'Aérophile*).

Machine	Rumpler 1916	Aviatik 1916	L. V. G. 1916
Engine	Mercedes 165 horsepower	Mercedes 170 horsepower	Mercedes 165-170 horsepower
Maximum speed on ground, miles per hour	92	93	95
Minimum speed on ground, miles per hour	..	49.5	..
Speed at 1,000 meters, miles per hour	..	84	87
Speed at 2,000 meters, miles per hour	85	82	84
Speed at 3,000 meters, miles per hour	81.5	82	..
Climb, in feet per minute	3,200 in 10 6,400 in 16 9,600 in 29	1,600 in 4½ 3,200 in 9½ 6,400 in 21½ 9,600 in 47½	3,200 in 12 6,400 in 33
Maximum altitude fully loaded, feet	14,800	11,200	10,000
Endurance, fully loaded, hours	4	4½	4½
Total weight, pounds	2,780	2,840	2,840
Net weight, pounds	1,830	1,860	1,860
Useful load, pounds	950	980	980
Percentage useful load	34.2%	34.4%	34.4%
Military load, pounds	580	550	550
Loading per brake horsepower, pounds	16.8	16.7	16.8
Loading per square foot of wing area, pounds	7.35	6.6	7.1
Overall length, feet	25.2	..	26
Total wing area, square feet	378	430.56	400
Upper span, feet	39.2	40.66	41.3
Chord, feet	5.4	6.1	..
Lower span, feet	35.4	35.4	36.4
Chord, feet	5.4	6.1	..
Gap, feet	..	6.3	..
Ailerons, square feet	27.8	..	22
Stabilizer area, square feet	35.4	35.2	37.6
Angle of stabilizer	— 1.36°	— 1°	..
Elevator area, square feet	18.2	12.07	16.2
Fixed vertical fin, square feet	4.8	3.2	5.3
Rudder, square feet	7.25	6.4	6.4
Dihedral of wings	2°	Slight	None
Angle of wings to body	5°	4.5°	4.25°
Decalage	None	Almost none	None
Stagger	None	Almost none	None
Sweepback	Slight	None	Slight
Armament	Pilot forward machine gun firing through propeller. Passenger in rear with circular gun-turret. Some of these machines also carry a bomb dropping device.	In rear seat pilot has two bomb-throwers in front of him. Passenger in forward seat has two adjustable gun supports, permitting him to fire in almost all directions. The propeller is protected by a circular plate.	Complicated arrangement for throwing bombs which sometimes weighs as much as 25 pounds. Two machine guns, one firing through the propeller, the other on a rotary turret in rear cockpit.

The Mercedes engine so largely employed on German airplanes has the reputation of being extremely reliable and efficient, but is considerably heavier per brake-horsepower than American engines of about the same power, an important fact to be considered when the American designer sets out to equal the German machine.

Twin-Engined Machines

The memorandum prepared in the office of the officer in charge of the Aviation Section, Signal Corps, U. S. A., gives

very interesting data on twin-engined seaplanes, reproduced in Table 5 herewith. It lays strong stress on the advantages of this type, partly on the ground that a thoroughly developed engine of over 200 horsepower had not yet been constructed; but since that time progress has been made and the 300 horsepower engine is becoming a practical possibility. Stress is laid on the versatility of the twin-engined machine. In a land twin-engined machine, with the engines supported on the wings, and a central body, it is suggested that the pilot with his controls could be placed in the rear cockpit in rear of the propellers; the observer with his machine gun, in the forward cockpit forward of the propellers; and the bombs and gasoline between the pilot and observer, near the center of gravity of the complete system. With such an arrangement, the observer would have an ideal field for observation and for gun fire; with a stabilizer the pilot could fight the machine to the rear, and the machine would be an excellent fighting airplane as well as a bomber. By decreasing the bomb weight, the radius could be increased to a very long range. A third man could be installed in between the front and rear cockpits by making slight alterations in the construction of the body. If the third man had charge of the controls, there would be an even better fighting machine. If neither bombs nor a third man were carried, the landing wheels could be replaced by two or three pontoons, giving a military seaplane.

TABLE 5.

Horsepower	260
Type	Pusher or tractor
Number of men	2
Military load, pounds	550 to 1100
Fuel load, pounds	600 to 1150
Miles radius of action, full power	450 to 600
Climb, feet in 10 minutes	3400
High speed, miles per hour	90
Low speed, miles per hour	47
Factor of safety	7.0
Percentage made in war	4

A further evident advantage of this type is that it could be flown with one engine out of commission. The propeller would not be required to take the great power of a 300 horsepower engine. Although the support of the engine on the wing presents considerable difficulties, yet this arrangement might react favorably on the weight of the wing structure by distributing the load, and therefore giving less bending moment to the inner wing panels.

If a single engine of 250 or 300 horsepower were used, the same military and useful loads would be available. With a single body the parasite resistance would probably be diminished. But the difficulties of constructing such a machine for fighting as well as bombing purposes would be very considerable. With the engine in front, it might be possible for the pilot to sit in the forward cockpit and shoot through the propeller, while in the rear the observer could operate a machine gun in all directions. If bombs and bombing apparatus were included in the single body, there would be an extremely difficult construction problem. If the high-powered machine were made a pusher, the rear occupant would be under difficulties as a machine-gun operator. The other possible alternative would be to place the observer in a cockpit forward of the propeller—which would revolve round the body—the engine behind the propeller, then the pilot in the rear seat. None of these arrangements seem to have the straight forwardness and simplicity of the twin engined type.

It would seem, therefore, that in spite of the development of a reliable 300 horsepower engine, the twin-engined machine would have much to recommend it.

The following points may be disadvantages of the twin-engined machine, or merely problems which careful design can overcome:

(1) There are difficulties in preliminary design. In the school machines, the armed and unarmed reconnaissance types, and in the speed scout, we have data to draw upon from which loading per square foot of wing area, loading per brake-horsepower, useful load, etc., can be at once fixed within certain limits. Here we have an entirely new problem. Theoretical considerations show that with increased span, the bending moment and other stress producing forces for geometrically similar machines vary as the cube of the span. The resistance of bracing wires would vary as the square of the span. The section modulus of the wing spars would vary as the span cubed, but their area, resisting direct tension or compression would only vary as the square of the span. Similar considerations would follow for other strength members. Even if we allow the structural weight advantage of engines on the wings as previously mentioned, the conservative designer would still expect weights to go against him. If the twin seaplane that he is designing follows the same outlines of construction that he has been accustomed to in a single-engined type, he should allow for a slightly heavier loading per horsepower and a slightly smaller loading per square foot of wing area, i. e., a larger wing area than he would, in the light of past experience, expect to employ. Such a conservative outlook—well founded in the author's opinion, particularly for experimental machines—would lead again to less favorable estimates of performance, and avoid the ridiculously optimistic estimates for these large machines in the recent bids. It is interesting, in the light of these remarks, to study the performances submitted in these bids for seaplanes. (AVIATION AND AERONAUTICAL ENGINEERING, December 1, 1916.) The Curtiss Company, with its past experience in the building of twin-engined machines (Twin JN), specified a climb of 2,000 feet and a speed of 65 miles per hour, although probably equipped with two 200 horsepower engines. The Wright-Martin Corporation was so conservative as to specify no performance. A great many optimistic bids were submitted. The average climb sent in appears to be 3,580 feet, the average maximum speed 77 miles per hour. One would be inclined to think that with present American methods of construction, a climb of 2,800 feet, and a maximum speed of about 68 miles per hour would be as much as could possibly be expected.

(2) Control surfaces and stability furnish interesting problems. The effect of placing the engines out on the wings is to increase the moment of inertia in roll, and it is very difficult to say what effect this will have on inherent lateral stability. It is certain that the aileron area required will be somewhat greater than that in a machine where the engine is at the center of gravity and that the machine will be slow to respond to lateral controls. The moment of inertia in yaws will similarly be increased so that rudder and vertical fin surfaces may have to be larger proportionately than on the usual machine. These are points requiring the most careful attention in design.

(3) Another problem in connection with the twin-engined machine is that of propeller slip from the two screws, both turning inwards. This symmetrical arrangement is prescribed by the Army specifications as avoiding torque and gyroscopic effects. The down stream from the propellers impinging on the stabilizer is said to increase the safety from the point of view of longitudinal balance, giving tail heaviness with power, and nose heaviness without power. The exact effects are, however, still open to experimentation.

Space forbids a discussion of numerous other points which this type presents. The appended references will give the reader some information. The German twin-hydro reproduced in AVIATION AND AERONAUTICAL ENGINEERING, September 15, 1916, is of particularly neat construction, the specification No. 1002 is almost a text-book on design, and the S. A. E. paper on twin-engined machines read by Capt. V. E. Clark, U. S. A., touches on a greater number of points than we are in a position to deal with. Anyone setting out to construct such a type would do well to devote considerable time to wind tunnel experimentation, computation of moments of inertia, etc.

References for Part II, Section 2

"GUN-CARRYING TWO-SEATER MACHINES."

"Rumpler," *L'Aérophile*, December, 1916.
"Aviatik," *L'Aérophile*, October, 1916.
"L. V. G.," *L'Aérophile*, November, 1916.
"Other German Machines," *L'Aérophile*, March, 1916.

PROPELLER AND MACHINE GUN SYNCHRONIZING MACHINES.

"Fokker Firing Mechanism," *L'Aérophile*, June, 1916.
"Twin-Engined Machines."
L'Aérophile, July, 1916 (abstract in AVIATION AND AERONAUTICAL ENGINEERING, Sept. 15, 1916).
"Some Problems in Airplane Construction" (S. A. E. *Bulletin*, December, 1916).
"Army Aeronautical Specification No. 1002."
"The Development of the Military Aeroplane," by F. W. Lanchester, *Engineering*, March 3, 1916.

Book Review

FLYING FOR FRANCE

By James R. McConnell, Sergeant-Pilot in the French Flying Corps

(Doubleday, Page & Company. Pp. 157. $1.00 Net.)

A vivid and interesting account of the daily work of the American escadrille of the French Flying Corps, particularly over Verdun and on the Somme front.

Chapter IV, "How France Trains Pilot Aviators," first appeared in AVIATION AND AERONAUTICAL ENGINEERING of November 1st, 1916, having been contributed by the author.

The book describes the manner in which Kiffin Rockwell, Victor Chapman and Norman Prince met their deaths while engaging enemy planes above the clouds, and pays high tribute to the courage and devotion of these young Americans.

Note on Stresses in Built-up Rectangular Bodies Due to Rudder Forces

By Alexander Klemin and W. B. Ford

The analysis of the stresses in the body is far from complete, and one of the stress producing causes, namely, the force on a rudder whose center of pressure is fairly high above the center line of the body, seems worthy of consideration. In this brief note, the wire and longeron stresses induced by the forces on the rudder are worked out for a single panel of a fairly typical rectangular body, with dimensions and areas of tail surfaces as shown in Fig. 1. Owing to the extreme complexity of the problem, a complete analysis is very difficult, and the results arrived at may be only approximately correct.

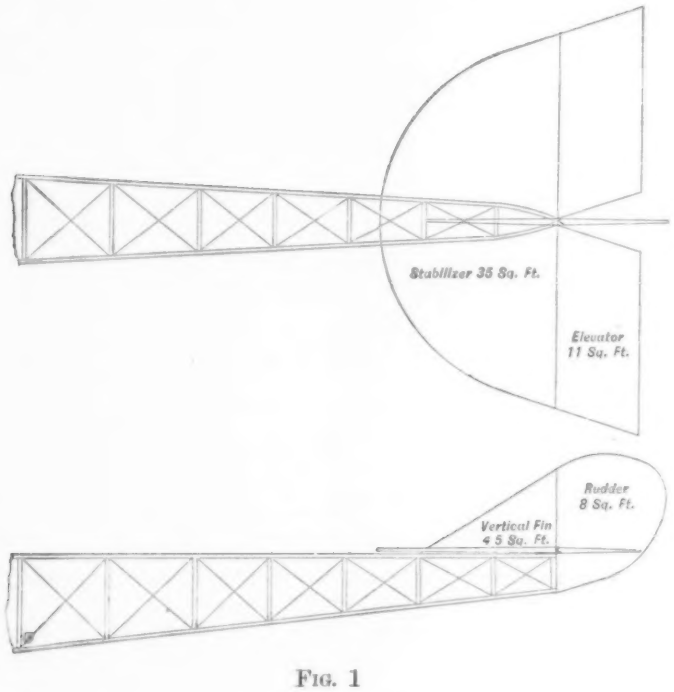


FIG. 1

If similar calculations, however, are applied to a machine which the designer has found satisfactory in practice, they will serve as a criterion for other machines, and at least remove an element of guesswork.

The rudder forces produce:

(a) bending in a vertical plane through the middle of the airplane.

(b) twisting about an axis passing through the centers of the transverse diagonal wires in any panel.

To allow for bending, it is sufficient to divide the rudder load equally between the upper and lower planes of the body, and to draw stress diagrams in these planes in the usual manner.

To allow for twisting, the following simple process can be followed: In Fig. 2 are shown diagrammatically the transverse diagonal wires, and the cross-members at one point of a body. Assuming that the twisting torque of the rudder about the point $O = T$, we may replace T by four forces, F_1, F_2, F_3, F_4, at the corners of the rectangle, at right angles to the diagonals OA, OB, OC and OD. Such that $F = \frac{T}{4a}$, the forces F acting in such a direction as to give a twisting moment of the same sign as the torque. The forces F can be resolved into two components F_H and F_V, as shown.

The following assumptions are made:

(1) That under the twisting action no appreciable distortion of the rectangle $ABCD$ occurs.

(2) That the wooden longerons oppose no resistance to the twisting and bending which might follow under action of forces F_1, F_2, F_3, and F_4.

It follows from these premises that no strain comes on the diagonal wires AC, BD, and that the whole of the twist is taken up by the tension of the wires in the four longitudinal planes of the body, and the consequent compression in the longitudinal and cross-members. A further analysis would be very complex, and this method has the advantage of placing the worst possible load on the members involved.

The forces F_H and F_V can now be resolved in the horizontal and vertical planes of the body in which they act respectively; they cannot be resolved into members which are in a plane at right angles to them.

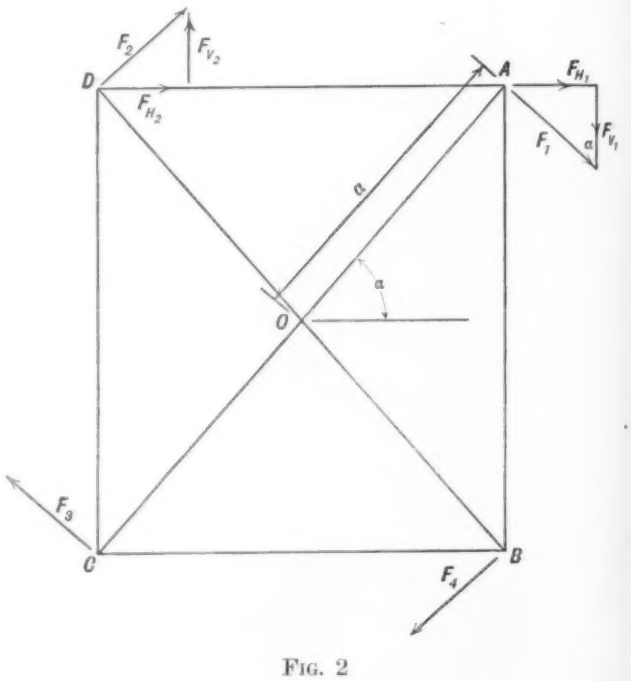


FIG. 2

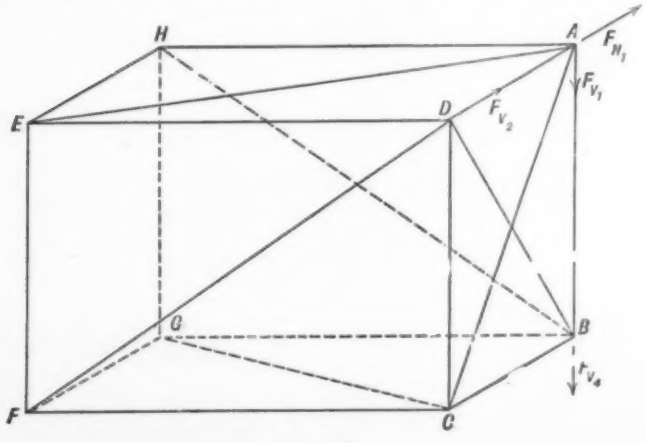


FIG. 3

Thus in Fig. 3, where only those wires which are in tension in the longitudinal plane are shown, F_{H_1} and F_{H_2} combine to give tension and compression in the members EA and H_1, the values being found by a simple resolution of forces together with a compressive F_{H_2} in the cross-member DA. Similarly F_{V_1} and F_{V_4} combine to give tensile stress in HB and compression in AB and GB.

In Fig. 4, F_{V_1} and F_{V_2}, the triangle of forces is shown for the plane HB. A similar triangle of force can be drawn for each of the four planes.

In the body, for one panel of which complete computations have been made, the following severe air load conditions were assumed:

(1) speed 100 miles per hour

(2) rudder of 8 square feet area turned at 20°, simultaneously with

(3) stabilizer at —6°, elevator at —20°, and diagrams were drawn in accordance with standard methods.

The landing stresses were also obtained from a stress diagram under the following landing condition:

Glide of 1 in 7, speed of 45 miles per hour, travel of shock absorber 6 inches.

The results are summarized in the following table:

Member.	Length.	Force due to elevator and stabilizer loads in pounds.	Force due to bending by force on rudder in pounds.	Force due to twisting of rudder torque in pounds.	Percentage increase allowing for rudder loads.	Force due to landing in pounds.
HA.....	24"	3600 T	758 T	190 C	26%	2500 T
ED.....	24"	3600 T	875 C	195 C	—29%	2500 T
FC.....	24"	4370 C	875 C	190 C	24%	3380 C
GB.....	24"	4370 C	758 T	195 C	22%	3380 C
EH.....	24"	....	70 C	168 C	..	....
FG.....	24"	....	70 C	168 C	..	....
DA.....	20"	....	87 C	168 C	..	....
CB.....	20"	....	87 C	168 C	..	....
FE.....	23"	687 C	...	175 C	26%	740 C
GH.....	23"	687 C	...	175 C	26%	740 C
CD.....	20"	750 C	...	175 C	24%	700 C
BA.....	20"	750 C	...	175 C	24%	700 C
FD.....	32.5"	...	...	257 T	..	....
EC.....	31"	1000 T	...	...	..	1140 T
EA.....	33"	...	...	262 T	..	....
HD.....	33"	...	112 T	...	..	....
HB.....	32.5"	1000 T	...	257 T	26%	1140 T
GA.....	32.5"	...	...	...	..	....
GC.....	33"	...	112 T	262 T	..	....
FB.....	33"	...	...	...	..	....

It is seen from this table that the effect of the rudder loads is by no means negligible, and that calculations of this kind are quite valuable. Such an air loading as we have assumed might very well occur after a steep dive, and the factor of safety would be considerably smaller than that which would follow from the ordinary calculations under Army specifications. Incidentally, it is seen that the stresses due to landing are sometimes of lower, sometimes of greater value than those

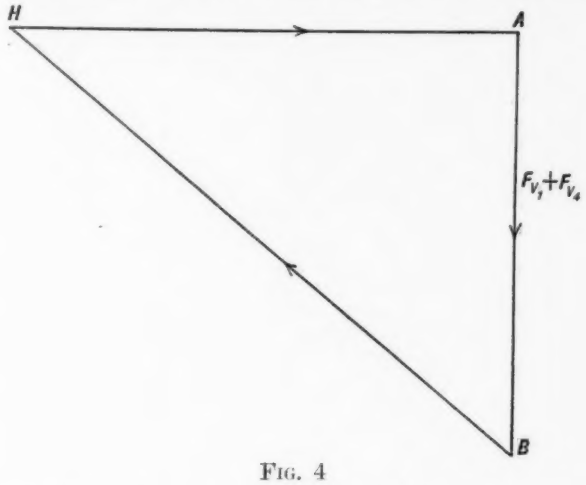


FIG. 4

obtained from the combined air loads, showing that it is advisable to carry through both air and landing stress calculations.

News of the Fortnight

Canadian Aviation Plans

The British Government has among its plans for Canada the establishment of a large number of reserve squadrons of the Royal Flying Corps, and the construction of airplanes on a large scale. For some time past the Imperial Munitions Board has been inspecting numerous sites for an aviation plant and school, and has selected Camp Borden as being the most adaptable for the purpose. The contract has already been let to the Bate, McMahon Company of Ottawa for the establishment at Camp Borden of a $3,000,000 aviation plant and school.

No sooner was the contract signed than machinery and an army of workmen were dispatched to the selected area, and operations have already begun. The location of the new establishment will in no way interfere with the training of the troops, as it is situated three-quarters of a mile from the training district.

The Curtiss Aviation School at Long Branch will be moved to Camp Borden and Colonel Hoare and his staff from the Royal Flying Corps will undertake the training of the Canadian airmen.

Flight at Army Balloon School

The new army balloon school at Fort Omaha celebrated Washington's birthday by the first ascension.

Capt. C. D. F. Chandler, commandant at the fort; D. H. Bower and Lieut. L. C. Davidson, went up in a brand new balloon at 4:50 p. m., and landed at Persia, Harrison County, Iowa, thirty-five miles northeast of Omaha at 6 o'clock. They were up in the air just the hour that is required by the army regulations in testing out a new balloon, which was the purpose of the trip.

Of the three officers, Captain Chandler was the only one who had ever made a flight before. He is a veteran, having participated in many flights, and having won several prizes.

The plant which generates the gas for the balloon has been only partially overhauled and it required intermittent efforts for days to fill the big gas bag.

E. M. HAGAR RESIGNS

E. M. Hagar has resigned from the presidency of the Wright-Martin Aircraft Corporation. He will become the president of a new subsidiary of the American International Corporation. No announcement has been made by the Wright-Martin Aircraft Corporation as to changes in its plans.

Bay Shore, Long Island, to Have Large Aeronautic Station

Word has just been received from Lieut. Lee H. Harris, who was in charge of the Naval Militia Aeronautic Station at Bay Shore, L. I., last summer, that Bay Shore is to become quite an aviation base this coming summer.

Lieutenant Harris and Ensign Ruttan are now at the United States Navy Aeronautic Station, Pensacola, Fla., where they were ordered Dec. 1. They have been taking an extensive course both in learning to fly the large Navy seaplanes and also in the airplane erecting shops and motor shops.

Plans have been drawn up and bids received for erecting airplane hangars, living quarters and mess hall at Bay Shore.

The Navy Department intends loaning to the Militia a large tractor seaplane with which to instruct and to use for scouting flights to sea. A fund is being raised to purchase another and larger seaplane capable of making a speed of 90 miles an hour, with a cruising radius of 400 miles.

These machines, together with the flying boat now on hand, will make the 1st Battalion, Naval Militia, N. Y., one of the best equipped volunteer aeronautic units in the country.

Lieutenant Harris expects to recruit the section up to its full strength of five officers and twenty-three enlisted men. Examinations are now being held so that the best material will be accepted.

It is anticipated, with the new equipment, to be able to turn out at least twenty aviators during the summer.

Legislation for Civilian Fliers

Legislation to enable the army to develop operators of airplanes and other air craft without the necessity of army enlistment has been urged upon the House of Representatives by James R. Mann, of Illinois, Republican floor leader.

During consideration of the Army Appropriation bill Representative Crago, of Pennsylvania, proposed an amendment to appropriate $1,000,000 for aviation purposes in the National Guard. Representative McKellar, of Tennessee, member of the Military Affairs Committee, vigorously opposed the amendment and finally made a point of order against it, which was sustained. He declared that the aviation profession was too dangerous to be placed in the hands of the National Guard and should be left to the regulars.

Representative Mann, while expressing doubt as to the wisdom of the Crago amendment, declared that some legislation should be enacted to authorize the army to train unenlisted volunteer aviators.

Men Wanted for Aviation Section

Aero squadrons are now being organized at San Antonio, Tex., by the regular army. There will be many vacancies for men possessing qualifications or experience in any of the following lines: Gas engines, motorcycles, woodwork, tentmaking, machinery, motors, trucks, drafting, electricity, tools, airplanes, automobiles, photography or office work.

All applications for this division must be made through the proper military channels. Full information concerning the squadrons can be received at any recruiting office.

Miami Notes

Philips Rader, with a passenger, made a night flight recently which proved extremely successful, the bright moonlight assisting the pilot materially.

There are now sixteen pupils at Miami being instructed for the army reserve, the number of pupils having doubled within the past few days.

Use of Aircraft in Saving Life and Property at Sea

By Captain B. M. Chiswell

U. S. Coast Guard

One of the important duties of the Coast Guard is the assistance of vessels in distress, the saving of life and property from the perils of the sea and the removal or destruction of derelicts and other dangers to navigation. The records of the service for the fiscal year ending July 1, 1916, show that floating property to the value of over ten and one-half millions was assisted; that derelicts to the value of over $100,000 were brought in and restored to their owners; that thirty of these derelicts, dangers to navigation, were removed or destroyed; that over twelve hundred persons were saved from death or imminent peril; and that over fifteen thousand persons were on vessels assisted.

Last Christmas day the steamer *Maryland* sent out an S.O.S. call reporting that she was leaking badly and in imminent danger of sinking and requesting immediate assistance. Two cutters picked up this call and hastened to the reported position of the *Maryland* to the southward of Nantucket South Shoal. Although they made a very thorough and systematic search they found no trace of the steamer or her ill-fated crew. It is natural to suppose that when this crew of thirty odd men found that their vessel was going down they took to their boats. The search from a ship for a small boat on the ocean miles from land is an almost hopeless proposition. These cutters did all that could be done by them with the equipment now at their command, but no trace of the *Maryland* or her crew was ever found.

The question naturally arises is there some other agency that might have been employed with better chances of success? A seaplane located on Nantucket Island, where a Coast Guard station would naturally be, would have picked up this call at the same time as the cutter and would have reached the spot in about four hours, 15 or 20 hours ahead of the cutter; then with her radio she could have kept the cutter fully advised and might have got into communication with the shipwrecked men themselves and advised them as to when and from what direction succor might be expected. Airplanes have been developed to a high state of efficiency in destroying human life. Is it not worth our while to see whether they cannot also be developed along the line of saving human lives?

CALLS FOR ASSISTANCE

Calls for assistance come to the cutters from various sources. Steamers equipped with radio report their own troubles and the troubles of other craft that come under their observation. Other vessels come in and from their first port of arrival report things they have seen at sea that they think the cutter ought to attend to. Stations along the coast are connected up with telegraph and telephone lines and they report marine mishaps coming under their observation. The *Onondaga* with headquarters at Norfolk, Va., and covering the coast from Cape May to Cape Hatteras received 86 such calls in one twelve-month period.

An inspection of the files of telegrams and radiograms of one of the cutters would reveal an infinite variety of marine mishaps. Vessels are reported on fire. A comparatively recent instance of this was the British steamer *Templemore* which caught fire at sea and was completed gutted. The crew were rescued by another steamer and the big steel hulk left adrift on the ocean. After a long search it was found by the cutter *Androscoggin*, towed into Boston harbor and turned over to the owners. This hull represented a half million or more dollars. Vessels are reported as having lost their rudder, with machinery disabled; shafts broken, propellers lost; steam vessels adrift at sea out of coal; sailing vessels dismasted, sails blown away or badly damaged, mutiny on board, some member of crew in urgent need of medical assistance; vessels as having been in collision and badly damaged; tugs as having lost their tows, the barges being adrift at sea, helpless, with crew on board; small vessels having been driven off shore and unable to get back; motor boats being long overdue and so on.

When a call for assistance is received by a cutter unless otherwise engaged on important work, she proceeds to the reported position and very seldom finds anything afloat, not anchored or stranded, in the position from which reported. A search is then instituted which may last for days or weeks until coal begins to run low when she has to return to port to replenish her bunkers. Sometimes the object sought is found a hundred miles or more from its reported position. In about 50 per cent of the cases it is not found at all.

A study of the history of our most troublesome derelicts shows that they are usually lumber-laden schooners, wrecked and abandoned, waterlogged and lying very low in the water, rendered practically unsinkable by the cargo of lumber confined below decks. Those wrecked south of Cape Hatteras drift with the Gulf Stream current across the lane of practically all of our coastwise steamers and finally up into the lanes of the Transatlantic steamers, a potential danger to shipping almost as serious as the iceberg that drifted across the path of the *Titanic*. The cutters are frequently called upon to search for these derelicts and one found and towed into port represents not only the removal of this potential danger but the recovery of valuable property that would otherwise be a total loss.

(C) Underwood and Underwood

A DERELICT

SEAPLANES MIGHT BE USEFUL

After every severe onshore gale, several reports are likely to be received and all the time lost in search could be most profitably employed in assistance oftentimes sorely needed. Moreover when found, it may be something that is not in urgent need while other poor devils are in grave danger. The cutter has no information as to which is urgent and which can wait without undue hardship.

Can we not try to develop something in the way of a reliable seaplane that can go to sea with a reasonable chance of getting back again, that can alight on and rise from a moderately rough sea, that can be navigated with reasonable accuracy, and that can send a radio message 100 miles or more to do the search work for the cutters, greatly increasing their efficiency and rendering travel on the high seas safer? If such a scout can be perfected it will be about fifteen times as efficient in search work as a cutter.

The Coast Guard is not entirely convinced that the time is ripe for such a machine and is asking Congress for just one unit which will be in the nature of an experimental station, future development to be dependent upon the success of the work at this unit.

Looking at this idea from another angle, bear in mind that the Coast Guard is by law a part of the military forces of the country, operating under the Secretary of the Treasury in times of peace and transferred by executive order to the Navy in time of war. The duties of Coast Guard aviators in times of peace and war will be identical, viz: scouting over the ocean. Moreover the training they will receive in their useful peace time pursuit will be ideal for their war time duties. The calls for assistance do not come in often when all conditions are favorable. They come at all hours of the day and night and more often in bad weather than in good. The country will be developing a corps of highly trained aviators who will be a valuable military asset in case of war, and who, in peace times, will be bringing in a handsome return on the money invested in the way of life and property saved and greater safety of travel on the sea.

Effects of Altitude on Aviators

By Yandell Henderson

Professor of Physiology, Yale Medical School

Atmospheric air in all places and at all altitudes has a practically uniform composition as regards the proportion of oxygen to those inert gases which we class for most purposes as "nitrogen." Accordingly the partial pressure of oxygen, which is the amount available for breathing at any altitude, varies proportionately to the barometer; and the barometer falls according to a definite curve as we pass upward from sea level.

It was a French physiologist, Paul Bert, who first demonstrated that the effects of lowered barometric pressure, or altitude, are wholly dependent on the decreased pressure of oxygen. He showed that in pure oxygen at 21 per cent of atmospheric pressure life goes on in practically the same manner as in air, which contains 21 per cent of oxygen, at the ordinary pressure. So also the breathing of an artificial gas mixture containing only 10.5 per cent of oxygen has the same untoward effects at sea level that breathing pure air has at an altitude of about 20,000 feet where the barometer is reduced by one half. By breathing a mixture of gases deficient in oxygen one can get an aviator's headache without ever leaving the ground.

These considerations are fundamental for the differentiation of the disorders induced by rarefied air—so-called mountain sickness or aviator's sickness—from the conditions resulting from work in compressed air, so-called caisson disease. It is clear that it is from the former and not at all from the latter that aviators suffer, but as the two disorders are sometimes confused a few words regarding the latter are in place here.

Caisson disease, known also as the "bends," "diver's palsy," and by other names, depends upon the fact that under the high pressure necessary for diving, tunneling and other work below water the nitrogen of the air dissolves in the blood and in the other fluids and tissues of the body in amounts proportional to the pressure. This in itself does no harm, and has in fact no effect upon the body, until the subject comes out of the pressure lock or the caisson, or rises from the depth of the sea where he has been working. Then the nitrogen which has been dissolved begins to diffuse out of the body. This also does no harm and has no effect unless the pressure under which the man has been working is so high, and the lowering of the external pressure so rapid, that the dissolved nitrogen separates in the form of bubbles. Such bubbles may form in the blood, in the synovial fluid of the joints, and even in the brain. They induce intense pain and even paralysis and death. In order for bubbles to be formed it is essential however that the pressure with which the tissues are in equilibrium should have been lowered more than half its absolute amount in a few minutes.

In the present state of the art of flying it is scarcely possible for an aviator to rise to a height of 20,000 feet, where the barometer would be about half of that at sea level, in a period sufficiently short to allow bubbles of nitrogen to form in this way. The disorders from which aviators suffer therefore are of a different class from those to which workers in compressed air are exposed.

EFFECTS OF LOW PRESSURE

When the study of the effects of lowered barometric pressure was begun it was supposed that the circulation might be primarily disturbed. The blood in the arteries of a healthy man is under such a pressure that if a glass tube were inserted vertically into one of the arteries of his neck, and the blood allowed to flow up the tube, the column of blood would come to rest at a height of from 5 to 7 feet above his head. Knowing that the air pressure is reduced at great altitudes, some of the earlier writers made the mistake of supposing that such a column of blood would rise higher, and that the blood vessels would be under a greater strain, and more likely to burst therefore, at a great altitude than at sea level. That which they looked for they found. One writer has left a lurid description of how while crossing a pass in the Andes he got off his mule and walked for a time to rest the animal. On the least exertion his breathing became tremendously oppressed, "his eyes bulged and his lips burst." The odd part of this is that in reality the blood vessels are under no greater strain at a high altitude than at sea level. When the air pressure upon the exterior of the body and in the lungs is reduced, a part of the gas (at least the nitrogen) dissolved in the blood rapidly diffuses out so that the gas pressures within and without the blood vessels are again equal just as at sea level. The idea is still prevalent that hemorrhages occur under low barometric pressures. However, among thousands of people whom I had an opportunity to observe on Pike's Peak during a five weeks stay at the summit, I saw not a single nose bleed except one which was caused by the forcible application of a hard object to the organ in question.

The only direct effect of changes of pressure are those which are felt in the ears and occasionally in the sinuses connected with the nose. The ear drums are connected with the throat and contain air at the prevailing pressure. If the pressure is lowered this air expands, and forces its way out through the Eustachian tubes into the throat. If the outside pressure is increased it sometimes happens, particularly when the subject has a cold and the Eustachian tubes are inflamed, that air does not pass readily into the middle ear. Accordingly the ear drums, or tympanic membranes, are forced inward by the pressure and may thus cause acute pain. Workers in compressed air are accustomed while going "into the air," i. e. into pressure, to hold their noses and blow at frequent intervals as a means for expanding the ear drums. For aviators this procedure would be needed only during very rapid descents.

We may now consider some of the facts of normal breathing, the general features of the disorders induced by oxygen deficiency, and the means by which the body readjusts itself to a lowered oxygen pressure and becomes acclimatized to altitudes. This topic forms one of the finest chapters in recent physiological advance.

MECHANISM OF RESPIRATION

The mechanism of respiration in man is controlled from the so-called respiratory center in the brain. This center, contrary to popular belief, is relatively insensitive even to wide variations in the supply of oxygen. A normal man breathes no more and no less either in depth or rate, and consumes neither less nor more oxygen, when given the pure gas to breathe than when breathing ordinary air or air in which the oxygen content has been considerably reduced. In this respect therefore the consumption of oxygen in the body differs markedly from that by an ordinary fire. On the other hand the respiratory center is acutely sensitive to even the smallest variation in the carbonic acid transported by the blood from the tissues to the lungs. It has been truly said that "over the oxygen supply of the body carbonic acid spreads its protecting wings."

When a man exercises vigorously he needs more oxygen than when at rest, and he gets it by the more active breathing. The cause of the increased breathing, or as physiologists say, its stimulus, is not lack of oxygen but the increased carbonic acid which the muscles produce when working, and which is carried by the blood to the respiratory center as well as to the lungs. If lack of oxygen were necessary to cause increased breathing we should be in trouble with headache, dizziness, nausea and even fainting every time we ran up a flight of stairs. The fact that the center responds to increased carbonic acid protects us from this discomfort.

The sensitiveness of the center to the stimulus is extraordinarily delicate. Accordingly the tension of carbonic acid in the air of the lungs and in solution in the arterial blood is maintained automatically by the breathing with great constancy under all ordinary normal conditions. Thus experimentally it has been found that a few voluntarily forced breaths, causing a slight over-ventilation of the lungs, are followed in most persons by a spontaneous cessation of breathing until the carbonic acid reaccumulates up to the normal stimulating amount.

The sensitiveness of normal respiration to carbonic acid and its relative insensitiveness to lack of oxygen are well illustrated by the following experiments:

(1) A man breathes into a rubber bag containing 20 or 30 liters of air. The accumulation of carbonic acid soon produces labored breathing followed by violent panting.

(2) In the other experiment the bag contains, in addition to fresh air, a sufficient amount of sodium hydroxide to absorb carbonic acid as rapidly as the subject exhales it. Under these conditions continued rebreathing of the air in the bag progressively reduces its oxygen; but this reduction in the absence of carbonic acid induces comparatively little increase in the respiration. In fact some persons (who manifestly would be particularly unsuited by nature for lofty ascents in balloons or airplanes) become unconscious and collapse from lack of oxygen, and they would die if the experiment were continued, without noticeable augmentation of breathing. In other persons there is some acceleration of breathing which partly compensates for the low oxygen. It is characteristic of the peculiar effects of insufficient oxygen that the subject in such an experiment as this is usually unaware of his own condition. He may exhibit an exhilaration similar to that induced by alcohol, and insist that he is all right and wishes to continue the experiment, even when his face is alarmingly blue and his hands are twitching and trembling so that he can hold nothing in them. If at this stage the person supervising the experiment pulls the tube out of the subject's mouth so that the latter again breathes normal air, he may collapse for a short time. Thereafter a headache of the frontal throbbing type with nausea develops gradually and reaches its greatest intensity only after several hours. It may last well into the day following.

EFFECTS OF ACCLIMATIZATION

It is altogether probable that if this experiment were repeated daily, without pushing it far enough to cause severe inconvenience, the subject would become so accustomed to oxygen deficiency that he would be able to ascend to much greater

altitudes than before, and with less danger of those disturbances of judgment and those incoordinations of the movements of the limbs which oxygen deficiency induces in wholly unacclimated persons. In fact Dr. J. S. Haldane, the eminent physiologist of Oxford University, with whom I have had the good fortune to be associated in investigations on the effect of altitude, tells me that in experiments which are not yet published in detail he has in effect carried this through upon himself by means of an air tight room. When thus acclimated he was able to withstand without discomfort an atmosphere so low in oxygen that unacclimated persons were affected as in the experiment above described.*

The explanation of the processes involved in such acclimatization of low oxygen and to ascents or residence at considerable altitudes was the particular object of an expedition which spent several weeks at the summit of Pike's Peak, Colorado, in the summer of 1911.†

The experiments performed upon the members of the expedition themselves, as well as observations upon hundreds of tourists who ascended the peak, together with the work of many physiologists on closely related topics in the past few years, have afforded a fairly clear explanation of the general features of acclimatization. In particular it appears that it is not the carbonic acid as such and alone which controls the breathing, but rather the reaction of the blood, that is the balance of all the acid and alkaline substances which the blood contains, or as it is now usually expressed, its hydrogen ion concentration. In this balance carbonic acid is ordinarily the most immediately important factor because it is produced so easily and in such amounts in the vital combustion and during work, and is eliminated so easily through the lungs. Other acids are produced less readily and are excreted comparatively slowly in the urine. They are nevertheless as important as carbonic acid in determining the effect of the blood upon the respiratory center. Indeed when present in amounts above normal they stimulate respiration to more than ordinary activity, and even to the point of actual panting and gasping for breath. The carbonic acid content of the blood is thus reduced far below normal. Evidently if the oxygen supply is deficient such an increase of breathing would afford some degree of compensation.

This condition of decreased alkalinity, or increased acidity, or so-called acidosis, occurs in disease, particularly in diseases of the kidneys and in the final stages of diabetes, and is then partially relieved by large doses of bicarbonate of soda. But the point of immediate interest here is the fact that the development and maintenance of a slight degree of acidosis is a normal and important element in the readjustment of the blood, which occurs in persons who live or who go frequently to high altitudes. Apparently a slight deficiency of oxygen induces a corresponding degree of acidosis—perhaps by the accumulation of incomplete combustion products, e. g. organic acids, in the blood, or more likely in some other way. This acidosis results in a compensatory readjustment of respiration, which reduces the carbonic acid content of the blood and increases the rate of breathing.

There are wide individual differences in the readiness with which this readjustment occurs. Thus in the Pike's Peak expedition I suffered the least of any of the party because I happen to be one of those who are endowed by nature with a rapid response of this sort. I had only a slight feeling of tightness across the forehead, and slightly less than my usual appetite for supper, eight or nine hours after our arrival at the Summit House. That night Dr. Haldane suffered from nausea and headache, but by the next night he was nearly restored. The other two members of the party, Dr. Douglas and Prof. Schneider, were however much less fortunate. Although they were both younger than either Dr. Haldane or myself, and certainly quite as strong for all the ordinary strains of life, they suffered from nausea and intense headaches for several days before becoming acclimated.

EFFECTS OF THE BLOOD

In the process of acclimatization as we observed it in ourselves the increased volume of breathing, although the most noticeable was not the only, and perhaps not even the most important factor. There was also a steady increase in the number of corpuscles in the blood and of the red substance, haemoglobin, which is the oxygen transporter. This increase required several weeks to become complete, and on the average amounted to about 30 per cent. This was confirmed by observations on persons residing on the Peak for several months each year. In a general way the fact that such an increase occurs was known before. It was not realized previously however how very exact the acclimatization is in relation to the barometer. As the result particularly of observations by Miss M. P. Fitzgerald, who worked in collaboration with the Expedition and made measurements on the breathing and on the blood of the inhabitants of towns at various altitudes in Colorado and later in the mountains of South Carolina, it appears that these functions of the body undergo an automatic readjustment in relation to the altitude above sea level which is almost as precise as the height of the barometer. The advantage of a blood richer in corpuscles and haemoglobin arises from the fact that the capacity of the blood to hold and transport oxygen is increased. A considerable degree of compensation is thus afforded for the incomplete saturation which may result from the low pressure of this gas in the air. Evidently blood containing 130 per cent of the normal amount of haemoglobin will carry as much oxygen when only 77 per cent saturated (since 130 x .77 = 100), as normal blood will when fully saturated.

Neither of the modes of acclimatization thus far discussed is however so important as is the peculiar capacity which the lungs develop at great altitudes of secreting oxygen into the blood up to a pressure actually higher than that in the air from which the oxygen is drawn. This peculiar example of vital activity in the lungs is as yet shrouded in the same mystery which surrounds all secretory activity—such as for instance the production by the kidneys of such a fluid as the urine from such a fluid as the blood: for a cubic centimeter of urine may contain several times as much salt as a cubic centimeter of blood. Until recently physiologists generally denied that the lungs could secrete oxygen and held that the gas passed into the blood wholly by the physical process of diffusion. Nevertheless this secretory capacity in the lungs, as the Pike's Peak Expedition and other work particularly by Dr. Haldane has shown, does exist and is measurable with considerable accuracy. For all those who make rapid ascents, like mountain climbers and aviators, it is by far the most rapidly developed and most important element in the ability to withstand low barometric pressures.

In ourselves on Pike's Peak it was noteworthy that during the first few hours the lips were distinctly blue, indicating incomplete oxygenation of the blood. Even on the second day however improvement in this respect began to appear, and before the week was over a practically normal color had returned. At all times thereafter a striking experiment was to draw a few drops of blood from a finger, and after thoroughly shaking it in a bottle with air blown out of our lungs, to note that it remained of a relatively dark venous color in contrast with the brighter color of the blood in the lips. This latter had had the advantage of the superior physiological oxygenation afforded by passage through the lung tissue, while the former had only the physical aeration of shaking in a bottle.

INDIVIDUAL VARIATIONS

This factor in acclimatization shows even wider individual variations than do the other two discussed. This is nowhere better exemplified than in the crowd of from fifty to several hundred tourists who come up to the summit of Pike's Peak every morning during the summer months. All have been elevated in the course of an hour from Manitou at 6,600 feet with a barometic pressure of about 600 mm. of mercury, to 14,100 feet and a pressure of only 450 mm. All have undergone approximately the same change in external conditions, yet the physiological reactions and symptoms vary greatly. Most of those who stay only the regulation half hour, to which the cog railway officials wisely limit the stop of the trains, escape with nothing worse than a headache. Usually this headache comes on after the descent, sometimes even several hours later. A few tourists usually decide to spend the night on the Peak so as to see the sun rise next morning. By supper time, after the last car has gone down, they generally wish that they had not been so bold, and before daybreak most of them are actively mountain sick. Nowhere are there finer sun rises seen under more unappreciative conditions. Large parties also come up at night on burros, reaching the summit about 3 A. M.; the sun rise often finds them huddled on the benches in the big waiting room of the Summit House, or prostrate on the floor under conditions which suggest the cabin of a ship in a storm at sea.

On one occasion a newspaper reporter who had been sent up to interview us for an "illustrated Sunday supplement" had scarcely arrived before his hand began to shake so violently that he could not push the button on his camera. He was becoming alarmingly blue and faint, and appeared to be on the point of losing consciousness, when we took pity on him: we made him sit down in front of an oxygen appartus, while one of us held the tube to his mouth—his own hands were too shaky to grasp it. In five minutes he was quite revived, and had regained his color and spirits. He recommenced his interview, but had not gone very far when he again became blue and faint, and begged for more oxygen. Under it he was again completely revived; but hearing the whistle of a train about to descend, he hurried into it. And we saw him no more.

In contrast to such cases are persons in whose lungs the power to secrete oxygen develops almost or quite as rapidly as they can climb. Thus the record for the greatest altitude attained by mountaineers, won by the Duke of Abruzzi and his party in the Himalayas, is 24,600 feet,

* *Organism and Environment as Illustrated by the Physiology of Breathing:* Yale University Press, 1917.

† Douglas, Haldane, Henderson and Schneider, *Philosophical Transactions of the Royal Society*, 1913, Series B, Vol. 203, pp. 185-318.

where the atmospheric pressure is only two-fifths of that at sea level. At this tremendous altitude the Duke and his Swiss guides were able to perform the exertion of cutting steps in the ice and climbing, although if blood were thoroughly exposed, as by shaking in a bottle, to the air which they were expiring, it would take up an amount of oxygen which would be insufficient to maintain life. They on the contrary were almost free from ill effects. To such an extent was this true that Dr. Filippi in discussing this point says that the fact of immunity admits of but one interpretation—rarefaction of the air under ordinary conditions of the high mountains to the limits reached by men at the present day (307 mm.) does not produce mountain sickness.

In this matter it is quite certain that Dr. Filippi was misled by the fact that in gradually climbing day after day to a higher altitude all the members of his party had become acclimated. This fact of acclimatization became very evident during our observations on Pike's Peak, and its dependence chiefly upon the development of the secretory power of the lungs occupied a more and more important position as the work developed. What may happen when men are entirely unacclimated may be illustrated by a quotation from a description of his symptoms by Tissandier, the sole survivor of a fatal balloon ascent in 1875:

TISSANDIER'S EXPERIENCES

"I now come to the fateful moments when we were overcome by the terrible action of reduced pressure. At 7000 metres (Bar. 320 mm.) we were all below in the car. * * * Torpor had seized me. My hands were cold and I wished to put on my fur gloves; but without my being aware of it, the action of taking them from my pocket required an effort which I was unable to make. At this height I wrote, nevertheless, in my notebook almost mechanically, and reproduce literally the following words, though I have no very clear recollection of writing them. They are written very illegibly by a hand rendered very shaky by the cold. My hands are frozen. I am well. We are well. Haze on the horizon, with small rounded cirrus. We are rising. Crocé is panting. We breathe oxygen. Sivel shuts his eyes. Crocé also shuts his eyes. I empty aspirator. 1.20 p. m., —11°, Bar. 320. Sivel is dozing. 1.25. —11°, Bar. = 300. Sivel throws ballast. Sivel throws ballast. (The last words are scarcely legible.) * * * I had taken care to keep absolutely still, without suspecting that I had already perhaps lost the use of my limbs. At about 7500 metres (Bar. 300 mm.) the condition of torpor which comes over one is extraordinary. Body and mind become feebler little by little, gradually and insensibly. There is no suffering. On the contrary one feels an inward joy. There is no thought of the dangerous position; one rises and is glad to be rising. The vertigo of high altitudes is not an empty word; but so far as I can judge from my own impressions this vertigo appears at the last moment, and immediately precedes extinction, sudden, unexpected and irresistible. * * * I soon felt myself so weak that I could not even turn my head to look at my companions. I wished to take hold of the oxygen tube, but found that I could not move my arms. My mind was still clear, however, and I watched the aneroid with my eyes fixed on the needle, which soon pointed to 290 mm. and then to 280. I wished to call out that we were now at 8000 metres; but my tongue was paralyzed. All at once I shut my eyes and fell down powerless and lost all further memory. It was about 1.30."

In this ascent the balloon continued to rise till a minimum pressure, registered automaticaly, of 263 mm. was reached. When Tissandier recovered consciousness Sivel and Crocé-Spinelli were dead. They were all provided with oxygen, ready to breathe; but all were paralyzed before they could raise the tubes to their lips. Tissandier's notes are characteristic of the mental condition when oxygen-want is becoming dangerous. The experiences of this party of unacclimated men contrasts strikingly with those of the mountaineers above quoted.

The practical conclusion to be drawn from such observations as these is that if time is allowed for a gradual acclimatization, or if for some time before the ascent, mountaineers or aviators are subjected to a gradually increasing degree of oxygen deficiency, the capacity of the lungs to secrete oxygen will develop to a degree sufficient in most cases, to afford protection against any altitude that a heavier than air machine has yet attained.

The Air Service Under Universal Training

On February 21 the General Staff plan for universal military training was transmitted to Congress by the Secretary of War. This plan is the result of careful study by military experts and has been drawn to meet the military needs of all branches of the service. Under this plan a military air service, both lighter-than-air and heavier-than-air, is contemplated as shown in Table 2. AVIATION AND AERONAUTICAL ENGINEERING takes pleasure in being able to present to its readers an authoritative, concise and accurate statement of the Army's aeronautic needs.

The plan contemplates a peace strength organization to include eight squadrons on foreign service, two each at Hawaii and in the Philippines and four on the Canal Zone, sixteen squadrons with the Mobile Army at home, thirty squadrons with the Coast Defenses of the United States and an expeditionary force constantly in training of two squadrons, besides school detachments which will need 1500 men. The lighter-than-air organization contemplates three balloon companies for foreign garrison, eight companies with the Mobile Army and fourteen companies with the Coast Artillery, besides the school detachments of 250 men.

Table 2 shows the exact apportionment of officers and enlisted men in both the heavier and lighter-than-air service.

The table indicates that the General Staff considers a total personnel of 11,283 officers and men sufficient for the aerial military needs of the United States. The

TABLE 1[1]

Organization and Duties	Personnel of an Aero Squadron Signal Corps												Number of Auto Trucks						Pistols or Revolvers
	Commissioned				Enlisted								Airplanes	Motorcycles	Combat Train[2]				Field Train[3] Baggage and Ration Section	Total
	Major	Captain	First Lieut.	Total	Master Sig. Electrician	Sergeant First Class	Sergeant	Corporal	Cook	Private First Class	Private	Total			Airplane Carriers	Machine Shops	Tanks	Other Airplane Supplies		
Headquarters	1	2*a*	..	3	3	1*c*	1*d*	1*f*	3	4*k*	2*k*	15	..	7	..	2	2	3	..	7
Supply Detachment	..	1*b*	..	1	..	..	1*e* 7*g*	7*h*	..	..	..	15	..	2	..	..	..	..	2	2
12 Sections	..	6	12	18	..	12	12	24	..	60	12	120	12	12	12	..	..	3	..	15
Total	1	9	12	22	3	13	21	32	3	64	14	150	12	21	12	2	2	6	2	24
Attached Q.M.C. Troops	..	..	..	..	..	..	2	..	..	..	..	2	..	..	..	..	..	..	..	..
Attached Sanitary Troops	..	..	1	1	..	..	1	..	..	2	..	3	..	..	..	..	..	..	..	..

[1] One aero squadron is organized for each division. When divisions are operating as parts of a Field Army the aero squadron may be detached from divisions and grouped under the immediate control of the Field Army Commander.

[2] Supplied by Signal Corps.

[3] Supplied by Quartermaster Corps.

Composition of each section.

a. 1 Adjutant, 1 Engineering Officer.
b. Supply Officer. — 1 Captain or Lieutenant.
c. First Sergeant. — 1 Sergeant, first class.
d. Mess Sergeant. — 1 Sergeant.
e. Supply Sergeant. — 2 Corporals.
f. Clerk. — 5 Privates, first class.
g. Chauffeurs (machine shops, tanks and 3 auto trucks with headquarters). — 1 Private.
h. Mechanics (machine shops, tanks and 3 auto trucks with headquarters.) —
k. Orderlies, buglers, clerks, etc. — 11

Army's air force would then consist of fifty-six squadrons of twelve fliers each, with three airplanes for each flier, or a total of 1656 military airplanes, besides school machines and experimental types, although of the 1656 planes only 552 would be for active service at any one time, the others being reserve planes.

NEW ORGANIZATION FOR AERO SQUADRONS

The General Staff is considering and will probably adopt the following organization shown in Table 1, for an Aero Squadron. While this plan has not yet received the approval of the General Staff it is expected that approval will be given in a few days. By the new organization tables the aero company as a unit is abolished and an aero squadron is made the smallest field unit of the Aviation Section of the Signal Corps. According to the table, each squadron is divided into twelve sections, each section having charge of one airplane. While only twelve airplanes to the squadron are shown in the table, this relates only to planes in active service. The eventual organization contemplates a reserve airplane and a dissembled airplane for everyone on active duty, making a total of thirty-six to each squadron, twelve of which will be on active service.

TABLE 2

Heavier-Than-Air

	Foreign Garrisons		Expeditionary		Home Force			
	Active Squadrons	Depot Forces	Active Squadrons	Depot Forces	Active Squadrons	Depot Forces	Schools	Total
Officers	163	8	41	2	865	23	204	1,306
Enlisted men	1,200	200	300	50	3,128	575	1,500	6,903

Lighter-Than-Air

Officers	45	..	15	..	348	11	34	453
Enlisted men	450	..	150	..	1,496	275	250	2,621

Total personnel Aviation Section under General Staff Plan for Universal Military Training 11,283

Navy Sends Out Proposals for "Blimps"

On February 26 the United States Navy Department sent out requests for bids on dirigible balloons. Bids will be opened March 6. These bids are sent out by the Bureau of Steam Engineering and the Bureau of Construction and Repair, jointly, and constructors are asked to state the price for one, two, four, eight and more dirigibles. Bidders can enter bids for dirigibles separate from the power plants. If such proposals are submitted the dirigible will include the gas bag and all that goes with it, while the power plant will include the engine, fuel tanks, airplane body, etc.

AVIATION AND AERONAUTICAL ENGINEERING presents below a condensation of the proposals sent out by the Navy Department:

THE CONSTRUCTION OF A NONRIGID DIRIGIBLE

This specification contemplates a nonrigid self-propelled dirigible for use in connection with coast or harbor patrol. It is intended that it shall be operated from a base on shore, but that it shall be possible for it to rest upon the surface of the water in good weather. The airship shall consist of a nonrigid envelope made of rubberized fabric and containing hydrogen under sufficient pressure to maintain the rigidity of the envelope. There shall be attached to the envelope vertical and horizontal fins and vertical and horizontal rudders, mooring line, rip panels, maneuvering and safety valves, ballonets or internal air sacks with means for their inflation. Beneath the envelope and supported thereby is carried upon a suspension a car or body containing the power plant, fuel, ballast, personnel, radio, etc.

The envelope fully inflated has a displacement of about 77,000 cubic feet, corresponding to a gross buoyancy of 5,275 pounds when inflated with hydrogen of good commercial purity and under normal conditions of barometer and temperature.

The length of the envelope is 160 feet and the maximum diameter 31.5 feet; maximum width over tail fins, 36.2 feet; the center of buoyancy is 69.2 feet from the nose; the height over all is 50 feet; horsepower of motor, 100; horsepower of blower engine, 2; maximum safe altitude, 7,500 feet. Designed maximum speed at an altitude of 600 feet, 45 miles per hour; endurance at full power, 10 hours; cruising speed, 35 miles per hour; endurance at cruising speed, 16 hours. Capacity of tanks, 100 gallons, 600 pounds. Total volume of both ballonets, 19,250 cubic feet. Reserve ballast tank in car, 300 pounds of water. Trimming tanks attached to envelope: Forward, 40 pounds of water; after, 50 pounds of water.

WEIGHT STATEMENT

Envelope	1,177
Gas valves and sight holes	36
Air ducts, valves, and manifold	54
Suspension	35
Ballonets	350
Fins and rudders	480
Running rigging	43
Car:	
Structure (including tank weights)	321
Engine, complete	568
Blower engine and blower	100
Starting crank for main engine	25
Lighting cells, wiring and lamps	30
Landing gear and floats	58
Miscellaneous fittings	57
Total "penalty weight"	3,334
Useful load:	
Pilot and observer	320
Instruments	100
Radio	250
Fuel and oil	670
Water ballast (including trimming)	390
Sandbag ballast	211
	1,941

A plan is furnished as a part of the specifications. In case of any discrepancy between the plan and specifications, however, the specifications shall prevail. The workmanship throughout shall be of the most thorough character and suitable for the purpose intended and satisfactory to the inspectors. Aluminum shall not be used for important strength members, nor shall any strength member depend for its strength upon brazing, welding, or soldering.

ARTICLES OF EQUIPMENT

Tachometer, gasoline air pressure gauge, circulating water and lubricating oil thermometers, oil-pressure gauge, longitudinal inclinometer, map boards, mooring rope, two gas pressure manometers, one ballonet air pressure manometer, altimeter, statoscope, compass, air speed meter, fire extinguisher (chemical sprinkler type). Search light.

FABRIC REQUIREMENTS

The contractor must show that the fabric factor of safety under normal running conditions for any part of the dirigible exceeds 8. The strength to be taken as a basis, to be found by the methods given below.

All fabric used in the envelope or ballonets to contain two or more plies of cloth, one of which is to be laid on a bias of 45 degrees. Sufficient rubber of proper quality shall be placed in the fabric to meet the requirements as to diffusion and weather-resisting properties, which are given below. The protective coating on the outside of the envelope shall be at least 0.4 ounce per square yard, and on the inside 0.2 ounce per square yard. No fabric in the balloon is to weigh over 12 ounces per square yard, and no fabric is to test less than 40 pounds per inch in the direction of any of the threads, either bias or straight, test to be made as described below: Fabric in the top of the balloon shall show an average strength over 60 pounds per inch for the four different directions of threads; or a strength over 100 pounds per inch in either warp or filler if the two piles are doubled straight together for a sample test.

MODEL TEST

Each contractor for one or more dirigibles shall construct a model of linear dimensions one-thirtieth the size of the balloon, made of identical fabric, provided with suitable suspension disposed in similar fashion to that on the full-size balloon. This model to be inflated (upside down) with water to correspond with the full-size balloon when inflated to five times its normal running pressure. This will mean on the model a head of water at the top equal to 12½ feet. Leave pressure on for 10 minutes.

TESTS ON COMPLETED ENVELOPE

Each envelope when completed shall be blown partially full of air and all fabric inspected from the inside against a light to detect small leaks. After inflation with hydrogen at normal operating pressure, the envelope must show a leakage of gas less than 1 per cent per day, with all valves and accessories in place. Envelope, with ballonets in place, after inflation with hydrogen shall be inflated to a pressure of 3 inches of water at lowest point and held there for one minute. This is three times the normal pressure for flight, but no defects shall be developed by this proof test.

MOORING EYE

The nose shall be reinforced by a doubling patch of fabric similar to that in the envelope and wood battens about ⅜ inch by 3 inches in section equally spaced, converging at the nose, every alternate batten to extend beyond the doubling 3 feet. An eye shall be provided in the nose for a mooring line. This eye will consist of a 1¾-inch metal thimble secured in an eye splice of a four-strand manila rope. The rope will be unlaid and the eight strands let in beneath the doubling patch, equally disposed radially, the ends of the strands frayed and the whole set in cement. The breaking strength of the mooring attachment shall be about 5,000 pounds.

Rip panels, four in number, shall be located as shown with a rip cord, dyed red, run from each through light agate guides to the pilot. By pulling the rip cord weak stops securing the end of the panel are to break and tear open the panels for rapid deflation in an emergency.

Grab ropes, eight in number, shall be secured to patches on envelopes. These to be 1½-inch circumference manila rope secured to crows'-feet of ¾-inch flax signal halyard stuff (braided of 3-ply thread in 8 strands of flax twine; breaking strength, 800 pounds).

Ballonets are located as shown. Their combined volume is 25 per cent of the total volume of the envelope. The relative sizes of ballonets are to be adjusted so that their displacements give equal moments about the center of buoyancy of the envelope when completely inflated. The ballonets are to be fitted with a suspension band of fabric running around the plane of symmetry to which a light flax suspension is to be attached. Sight holes of transparent material are to be placed in the envelope for inspection of this suspension.

The lower part of the ballonet to be secured to a patch of doubled envelope fabric sewed and cemented to the envelope. This patch when removed carries with it the ballonet and windpipe connection. A sight hole shall be located in the ballonet patch for inspection of inside of ballonet. The safety valve will be located on top of the envelope. Construction of the valve is shown on detail sheet. This valve is to automatically open outwards when pressure in

envelope at lowest point exceeds 1 inch of water. The maneuver valve will be located under the envelope and will operate as a safety valve also, but may be opened by means of a line to pilot's seat. These valves are to be tested for tightness of seat and the spring loading adjusted as stated on the detail plan before installation. The belly band or suspension band is to be a heavy fold of canvas running round the lower part of the envelope, bearing at intervals hardwood toggles for the crows'-feet of the car suspension. This band shall be securely sewed and cemented to the envelope in a manner which on test is shown to develop the full strength of the latter fabric.

Fins

Stability of route is assisted by two horizontal fins and three vertical fins as shown. These fins are to be 170 sq. ft. in area each, except the vertical fin shown on top of the envelope, which will be 80 sq. ft. area, and are to be made up of a light structure of steel tubing and wood with internal wire bracing and covered with airplane linen treated with five coats of dope and varnished to give a smooth, taut surface. The fins to be braced by wires with turnbuckles, and crows'-feet to doublings on the envelope. Weight of fins to be kept down to one-half pound per square foot. Doubling patches shall be fitted on envelope to secure butt edges of fins by lacing.

Rudders

Two horizontal rudders, each 70 sq. ft. area, and two vertical rudders, each 35 sq. ft. area, are to be provided. Both the horizontal and vertical rudders are to be balanced and to work in ball bearings. Rudders to be securely trussed and operated by nonconducting leads (flexible cable of flax line) passing through agate guide rings, or ball bearing bronze sheaves as indicated on the plans. Rudder operating leads to give the least number of turns to reduce friction to a minimum. Fins and rudders to be readily detachable.

The car is to be electrically insulated from the envelope and no valve or other operating leads shall be of continuous wire. All metal parts in car are to be electrically connected. Metal parts of valves and their seats, wherever located, shall be electrically connected.

Steering Controls

All steering controls shall be in duplicate and interconnected.

Tanks shall be provided and arranged substantially as shown on general arrangement plan, sufficient for a 10-hour supply of fuel and oil at full power for the engine. The main fuel tanks shall be interconnected and so arranged that fuel may be taken from any tank or combination of tanks. Valves shall be operated from the rear seat and shall be quick acting. Fuel tanks shall be of noncorrosive material. If copper tanks are used, they shall be tinned on the inside. Tanks shall, before installation, be tested to an internal pressure of 5 pounds per square inch and must show no permanent deformation.

The water-ballast tank shall be located in the body and be of 300 pounds capacity, and provided with means for rapid discharge from the pilot's seat. The tank is to be made of waterproof fabric and shall be tight when full.

In addition to trimming the dirigible by manipulation of horizontal rudders or shifting air between ballonets, small water containers are to be placed near the bow and stern of the envelope, fitted with spring loaded valves, and means whereby such valves may be pulled open by the pilot. The forward tank shall contain 40 pounds of water and the after tank 50 pounds of water, and these tanks shall be located at the points shown in the general arrangement plan. The forward tank should be a fabric tube laced along a meridian with a valve in its lower after end. The after tank shall be as flat as possible and secured in a fabric pocket under the envelope and between the lower vertical fins.

Blower System

A 2-horsepower, 900 revolutions per minute engine of motorcycle type is to be arranged to drive through a 2 to 1 gearing a multivane blower of a capacity of 600 cubic feet per minute against a head of 2 inches of water. A crank is to be provided for starting the motor, which is to be accessible from the rear seat. Precautions similar to those stipulated for the main engine shall be provided for the blower engine to prevent flame from back fire or exhaust.

The radio outfit will be supplied by the Government.

Car

The car or body is of standard airplane type, consisting of a rigid rectangular girder of spruce trussed with wire. The engine and radiator are to be mounted forward, with a sheet steel fire bulkhead behind them; next the pilot with all controls and instruments; next the observer with duplicate controls and radio key; next the blower and radio outfit; next a fabric tank for water ballast; and last the gasoline tanks for 10 hours at full power. Reserve oil and gravity gasoline tanks may be mounted near the engine as shown on the plans. The car is to be inclosed with airplane linen except over the engine, where the covering shall be of sheet aluminum. The engine compartment shall be well ventilated and the bottom perforated to prevent accumulation of gasoline in case of leakage.

The department will supply and the contractor install a sprinkler type of chemical fire extinguisher with nozzles located near carburetor.

The negative buoyancy of the ship on landing will be carried by skids of ash, to which are securely strapped, as shown, waterproof fabric cylinders stuffed with kapok fiber. The cockpits shall be of convenient size, seats and rims well upholstered, and arranged to insure the comfort and convenience of the pilot and observer.

The pilot who is in the forward seat shall have all necessary and specified instruments and means for control of the ship. In particular his instrument board shall include two independent and different means for measuring the pressure of hydrogen in the envelope. The car shall have a jackstay along top and stirrups under bottom, as shown, to enable a man to reach engine or gasoline tanks in the air. The maximum propeller diameter permissible is 8 feet 6 inches.

Suspension

The car is to be suspended from the envelope by means of galvanized-wire cables with breaking strength of 2,700 pounds, arranged as shown. The cables are to be fitted with means for adjusting their lengths to equalize the load. The cables are connected to the suspension band by crows'-feet of braided flax, ¾-inch signal halyard stuff, as specified elsewhere. To carry the car when the dirigible is inclined the upper ends of suspension cables are connected by a fore and aft stay as shown.

The suspension cables shall be connected to the car by hooks or bolts arranged to permit ready detachment.

Power Plant

Includes engine, propeller, radiator, starting device, gasoline and oil tanks, piping, controls, gasoline and oil gauges, pressure gauges, thermometer, power-transmission system, tachometer, necessary shipping crates, etc., in order for flight, and as per the following specifications:

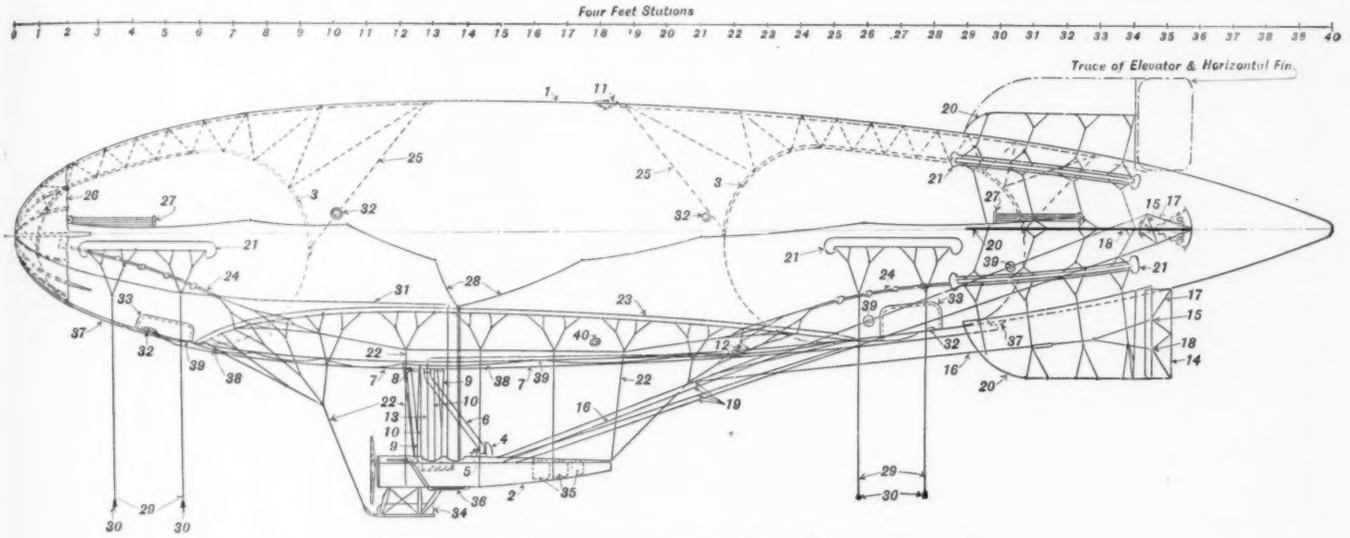
The engine shall be a standard Curtiss OXX-3, 100-horsepower aviation engine, or a Hall-Scott A-7-A, 100-horsepower aviation engine. The engine shall be provided with an effective starting device, so fitted and installed that engine may be easily started from the front seat. If hand starting is used, a booster coil will be provided.

Engine Tests

Each engine shall, before shipment from the factory, be subjected to a one-hour full-power run on propeller.

With each dirigible the contractor shall deliver the following:

1 ground cloth, 170 by 35 feet, 100 sand bags holding about 40 pounds of sand each, 1 filling balloon or service gas reservoir of 700 cubic feet capacity, 5 screw stakes, 1 extra mooring rope, 200 feet filling tube, 6 inches in diameter, with connecting sleeve, 1 roll of each weight of fabric used, 1 fabric stitcher, 1 fabric roller, 5 gallons of cement, 100 feet of each size wire or cable used, 100 feet of each size rope used, 1 spare gas safety valve, complete, 1 spare gas pressure manometer, 1 set of each size bolts, sheaves, guides, shackles, thimbles, turnbuckles, toggles, or other miscellaneous fittings used—list to be approved by the naval inspector.



General Arrangement Plan for New Navy "Blimps"

1. Gas Envelope
2. Car
3. Ballonet
4. Blower Intake Pipe
5. Engine for Blower
6. Main Air Discharge Pipe
7. Air Pipe to Ballonet
8. Air Manifold
9. Operation Cord, Ballonet Exhaust Valve
10. Operating Cord, Butterfly Valve
11. Valve, Pressure Relief
12. Valve, Maneuver Gas
13. Operating Cord, Maneuver Valve
14. Rudder—Twin
15. King Post
16. Leads, Steering Gear
17. Bracing Wire
18. Elevator
19. Leads for Elevator
20. Fin, Stabilizing
21. Doubling Patch
22. Car Suspension
23. Belly Band
24. Webbing
25. Ballonet Suspension
26. Nose Reinforcement
27. Rip Panel
28. Rip Cord
29. Grab Ropes
30. Weights
31. Mooring Rope
32. Sight Holes
33. Patch for Removing Ballonet
34. Kapok Floats
35. Fuel Tanks
36. Muffler
37. Trimming Tanks
38. Operating Cords, Trimming Tanks
39. Guides for Operating Cords
40. Filling Hole and Doubling Patch

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Nor upon two or three. It is distributed and redistributed throughout the entire tire, over *many* layers, established one upon the other.

These many layers are laid diagonally around the tire, expertly brought taut to share their rightful portion of the load, and made fast.

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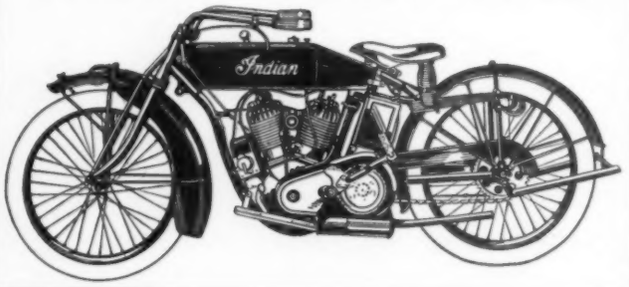

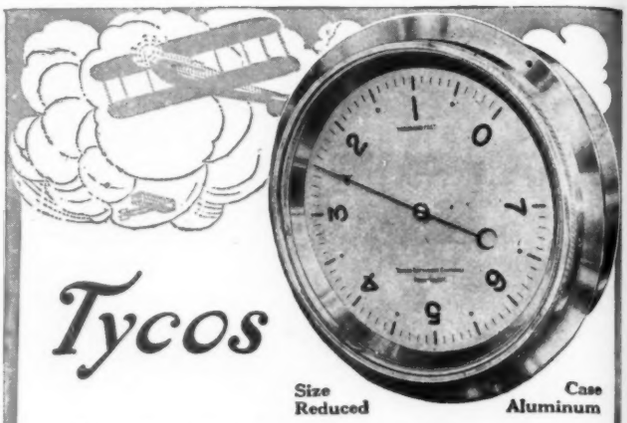

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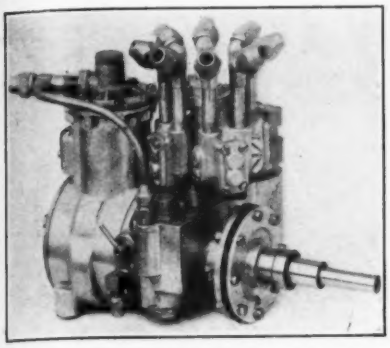

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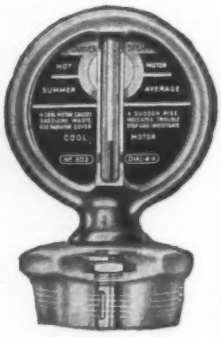

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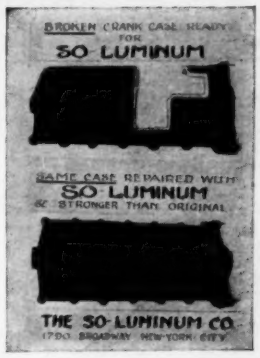

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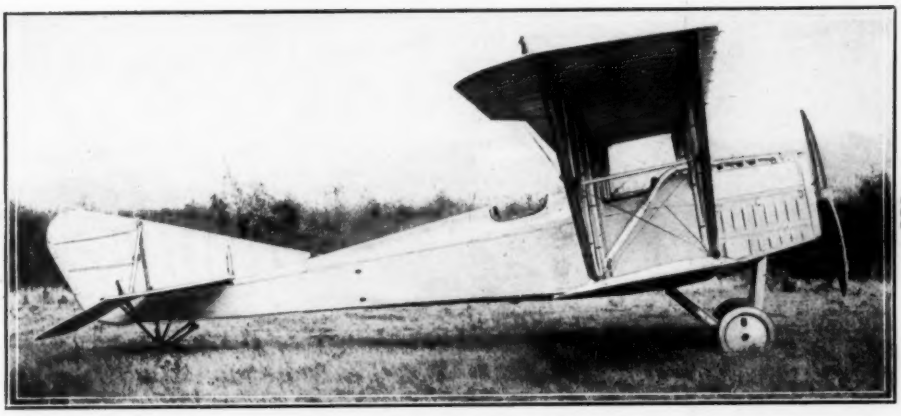

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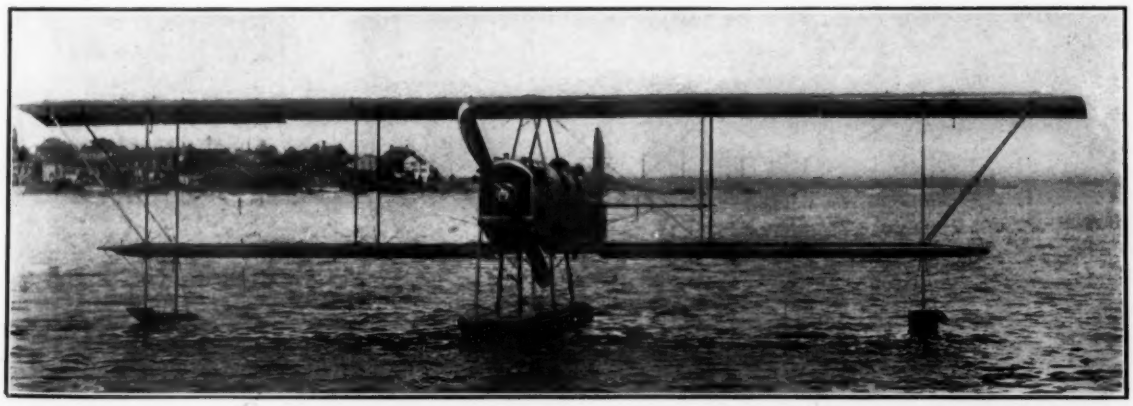

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